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Ministry of Energy
Ontario

Ontario Energy Review

Second edition

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Ontario Energy Review

Second edition

Ontario
Ministry
of
Energy

Hon. Robert Welch
Minister
Malcolm Rowan
Deputy Minister

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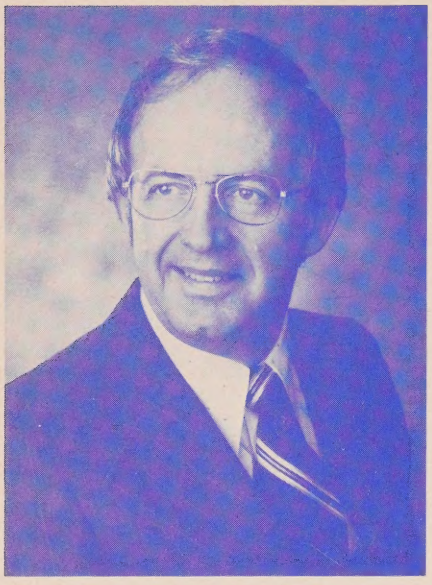
Foreword



I am pleased to introduce the second edition of the Ontario Energy Review.

We are grateful for the kind comments and expressions of interest that many of you forwarded to the Ministry after publication of the first Ontario Energy Review in the summer of 1979.

This edition gives greater emphasis to energy conservation and to alternative forms of energy such as propane, ethanol, methanol, hydrogen, fusion, and solar energy—all sources of energy which will gain wider usage in coming years as they become more feasible from both an economic and a technological viewpoint.

To summarize, the Review contains the most recent statistics available on energy in Ontario and explains them for those who are not specialists in the field. It is my hope it will help the public generally gain a wide understanding of energy matters in our province.

Robert Welch

Robert Welch
Minister of Energy

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Energy Ontario

Overview

Ontario obtains about three-quarters of its energy supplies from beyond its borders, primarily from other parts of Canada but with some from abroad. The province is therefore extremely vulnerable to changes in energy supplies and prices which occur because of events beyond its border.

The uncertainties of world energy supply have recently been underlined by the crude oil production cuts due to the Iraq-Iran war. Canada is better able than most countries to withstand prolonged world oil shortages because of its large undeveloped reserves of fossil fuels and its resources of water-power and uranium.

Canada today has to import about 20 per cent of its oil requirements. Over the next few years, this import dependence is likely to grow, and Canada's vulnerability to international upheavals will remain. However, Canada has the potential to become self-sufficient.

Developing Canada's remaining fossil fuel reserves will be expensive, because they consist mainly of heavy oil deposits, oil sands, coal, and frontier and deep basin oil and gas, all of which require vast amounts of capital to develop. However, if these reserves are developed in a timely fashion, and if Canadians are more efficient in their use of energy and substitute more abundant fuels for oil wherever feasible, Canada's and Ontario's future energy supplies can be assured.

Ontario's population is expected to grow more slowly than it has in the past. Higher energy prices and increasing conservation awareness will compound this effect, resulting in future energy requirements growing at much lower than historic rates. Moreover, as pointed out in the Ministry of Energy's 1977 publication *Ontario's Energy Future*, over the next fifty years Canada and Ontario will have to reduce their reliance on crude oil and natural gas and turn increasingly to energy from renewable resources.

In its 1979 policy paper *Energy Security for the Eighties* the Ontario government announced targets for energy conservation and substitution of alternative fuels for those based on crude oil. The targets were revised in October 1980. The new objectives established, for example, that by 1995 Ontario will reduce its dependence on other jurisdictions to less than 63 per cent of its primary energy requirements and will provide at least 5 per cent of its primary energy from renewable sources other than hydro electricity.

This Review is in two parts. The first part, Energy Update, outlines recent trends in the supply and consumption of each type of energy used in Ontario and examines the province's energy production and distribution networks. It looks next at changes in energy prices and then reviews provincial initiatives in developing forms of renewable energy and in implementing conservation programs.

The first section of the Energy Update outlines the major energy forms now in use in the province, shows where they come from, and discusses recent trends in consumption.

It is shown that prompt development of the Canadian oil sands and frontier oil reserves are essential elements of a strategy to protect Canada and Ontario against world oil supply shortfalls and from extreme world oil price fluctuations.

At present Canada has an oversupply of natural gas, which can substitute for crude oil in a number of heating applications. If new transportation systems are put in on schedule to connect frontier sources of supply, natural gas availability should not be a major concern to Ontario this century.

Although the three western provinces have vast reserves of coal and lignite, transportation costs remain a formidable obstacle to their widespread use in Ontario. Supplies from traditional sources in the United States seem secure for the foreseeable future.

The limits to future development of Ontario's hydroelectric sources are in sight. Their formerly dominant position as the source of Ontario's electricity is being assumed by nuclear power based on Ontario uranium and the Canadian CANDU reactor. The rapid growth of nuclear technology has reduced the need for increased reliance on coal for thermal electricity generation.

The Energy Update then summarizes recent energy price increases, showing Ontario to be fortunate compared to other jurisdictions.

From there the Review considers the progress of Ontario's strong commitment to the development of renewable energy, widely regarded as crucial to the province's long-term energy future.

Finally, the importance of provincial energy conservation programs is discussed and illustrated.

How Ontario's energy picture may change from now to the year 2000 is examined in the Energy Outlook section. Based on a number of assumptions, possible energy consumption patterns are projected for the province, and the prospects of adequate supply are explored.

In summary, the finding of the Energy Outlook is that Ontario should be able to avoid an energy supply shortage during the next twenty years, barring curtailment of crude oil imports from the oil exporting countries and provided that Canadian oil sands, heavy oil, and frontier energy sources are developed expeditiously.

Ontario's energy

Ontario's energy comes in several different forms. Most people, if asked to name them, would probably mention electricity, oil, and natural gas; a few would remember coal. To make the matter clear, however, it must be remembered that electricity is not a primary energy source like the others. It is a secondary energy source generated in Ontario mainly from water-power, coal, and uranium, and to a very small extent from oil and natural gas. Readers unfamiliar with the difference between primary and secondary energy forms should consult the diagram in 'Energy forms and conversion factors.' This distinction enables us to complete the picture of Ontario's primary energy sources shown in Figure 1, where primary energy used for electricity generation is indicated by the vertical coloured bands.

Crude oil meets about 41 per cent of Ontario's primary energy needs, natural gas meets 21 per cent, coal 14 per cent, water-power 13 per cent, and uranium 10 per cent.

The forest products industry burns its mill residues to supply part of its own energy needs. This use of solid wood waste and spent pulping liquor amounts to about 1.5 per cent of total Ontario consumption. Some wood is also burned for domestic heating, but the total amount is small at present.

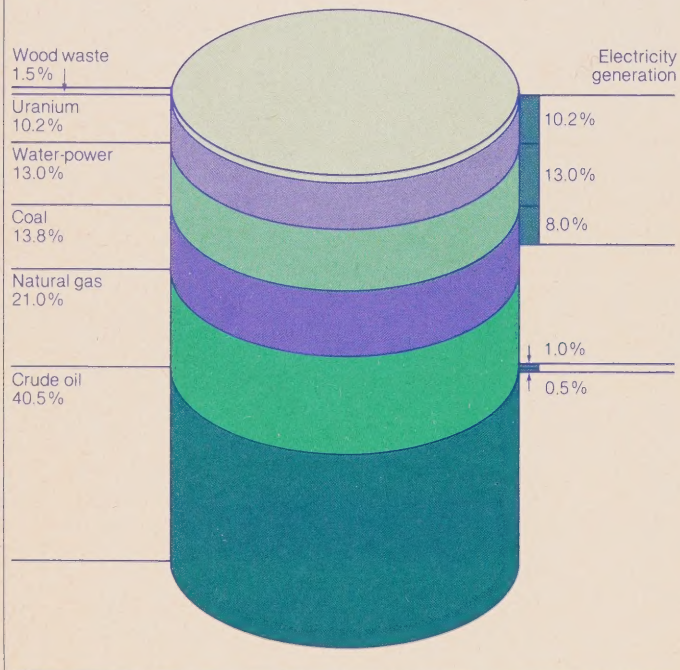
The energy picture for Canada as a whole looks rather different from Ontario's (Figure 2). Crude oil meets 43 per cent of Canada's needs, natural gas meets 19 per cent, and coal 8 per cent. But hydraulic sources meet 23 per cent of Canada's needs, twice the proportion in Ontario. Uranium supplies roughly the same proportion of Canada's energy requirements as wood waste. More than half the Canadian consumption of wood waste occurs in the forest products industry in British Columbia, whereas virtually all the uranium is used for electricity generation in Ontario.

Ontario itself produces only about one-quarter of the energy it consumes, mainly in the form of electricity, primarily from water-power and uranium. Only very small amounts of oil and natural gas are produced in this province.

The bulk of Ontario's energy, nearly 60 per cent, comes from other provinces, chiefly Alberta (Figure 3). Nine-tenths of Ontario's oil and virtually all its natural gas come from western Canada. About 17 per cent of Ontario's energy supply is imported from the United States, comprising some oil and much of the coal used in the province.

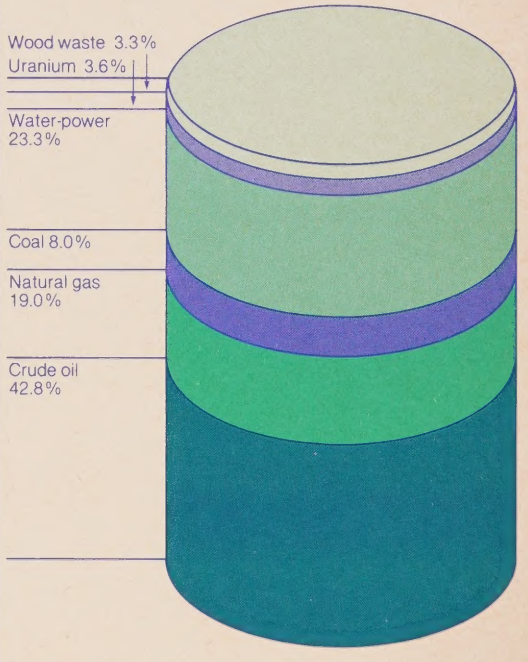
Ontario also exports some energy, mainly electricity and heavy fuel oil to the United States, equivalent to about 9 per cent of the province's energy requirements. Almost all the electricity Ontario exports to the United States is generated from imported coal.

FIGURE 1: Ontario's primary energy consumption 1979



Total consumption: 3440 PJ (90 million cubic metres of oil equivalent)
3260×10^{12} BTU (560 million barrels of oil equivalent)
■ Total primary energy used for electricity generation: 32.7%

FIGURE 2: Canada's primary energy consumption 1979



Total consumption: 9900 PJ (254 million cubic metres of oil equivalent)
9400×10^{12} BTU (1620 million barrels of oil equivalent)

Figure 4 shows that with our cold climate, long distances, and industrial structure oriented to the extraction and processing of natural resources, Canadians consume more primary energy per capita than citizens of any other large industrialized country. The United States, which comes next, uses about 9 per cent less per person than Canada.

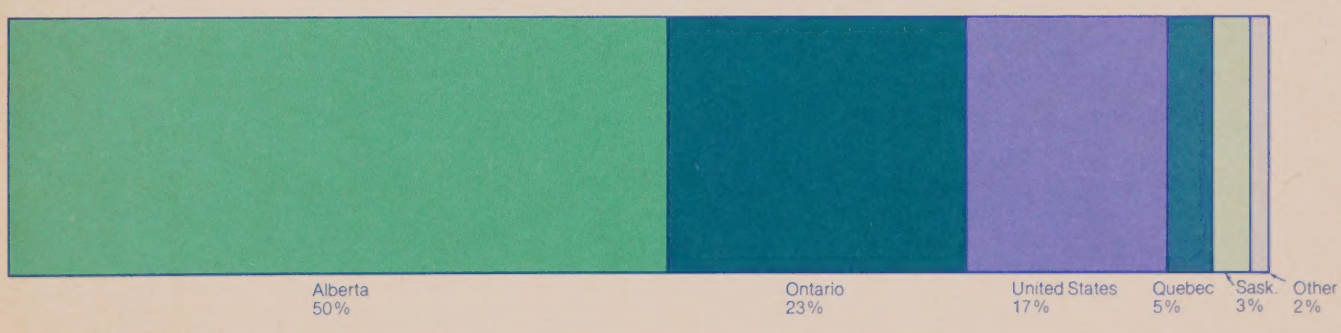
With this general picture in mind, we turn now to consider past trends in the supply and consumption of each type of energy. We shall then be able to review with some understanding the recent energy price changes. After that we shall examine the possibility of using untapped renewable energy sources and increasing the efficient use of energy through conservation programs.

FIGURE 4: World primary energy consumption for 1979

Country	Consumption/capita	
	GJ	Barrels of oil equivalent
Canada	391	63.9
United States	358	58.4
Netherlands	222	36.4
Sweden	220	36.0
West Germany	189	30.8
USSR	180	29.5
United Kingdom	154	25.2
France	150	24.5
Japan	136	22.2
Italy	107	17.4
Spain	87	14.1
China	27	4.5

Note: Primary energy comprises crude oil, natural gas, coal, water-power, and uranium.
Source: *BP statistical review of the world oil industry 1979*; populations from *International Petroleum Encyclopedia 1980*

FIGURE 3: Ontario's primary energy sources 1979



Western Europe, Japan, the United States, and Canada account for more than 60 per cent of world oil consumption but for only 22 per cent of production (Figure 5).

Between 1969 and 1979, world oil production increased by about 50 per cent. In 1979 world oil production was about 10.4 million cubic metres a day (m^3/day), about one-half of that amount being produced by OPEC countries.

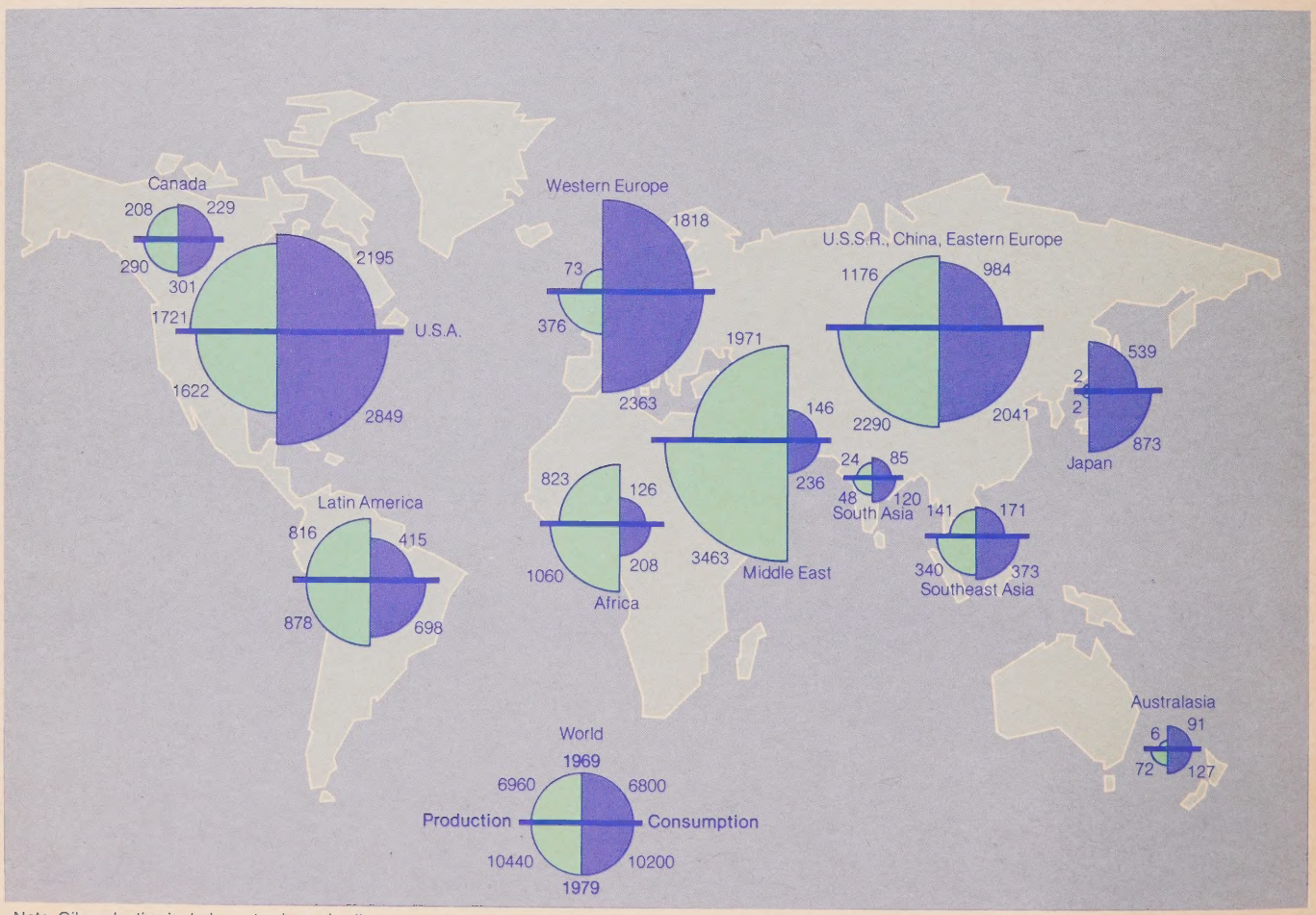
The world's proven crude oil reserves stood at an estimated 102 billion cubic metres at the end of 1979 (Figure 6). Saudi Arabia alone holds one-quarter of those reserves. Altogether the OPEC countries including Saudi Arabia hold about two-thirds of the world reserves. With its majority share of reserves, clearly OPEC's influence on the supply and price of the world's oil is not about to decline.

Forecasts of the future supply and requirements for crude oil are not encouraging. The International Energy Agency forecasts that there may not be enough crude oil to meet world oil requirements as early as 1985 (Figure 7). Even the growth in oil demand assumed in this forecast is modest by historical standards. Unless strong conservation efforts are made it could be exceeded if general economic conditions improve unexpectedly.

While there may be brief shortages, during which emergency supply arrangements would be required, eventually the market will tend to bring supply and demand into balance. Traditionally the world market mechanism has achieved that balance through prices. Indeed, the OPEC nations have shown they can raise prices almost at will whenever demand has exceeded capacity.

With the prospect of tightening oil supplies in the long term, world oil prices will become even more unpredictable. Furthermore, crude oil production in the countries of the Middle East and in other oil-exporting nations is being increasingly restricted by government policy. In 1980 the uncertainty of supply was underlined when 795 000 m^3/day of production was lost after the outbreak of hostilities between Iran and Iraq.

FIGURE 5: World oil production and consumption 1969 and 1979 (thousand cubic metres/day)



Note: Oil production includes not only crude oil but also shale oil, oil sands production, and natural gas liquids.
Source: *BP statistical review of the world oil industry 1979*

Canadian crude oil

Canada is not self-sufficient in oil. In 1979 Canada produced 256 000 m^3/day of crude oil and equivalent hydrocarbons and consumed about 300 000 m^3/day. Canadian production includes synthetic crude oil from oil sands, which averaged 15 000 m^3/day during the year. Canada imported about 97 100 m^3/day of crude oil but also exported about 45 900 m^3/day to the United States, so that net imports were 51 200 m^3/day, about 17 per cent of the country's requirements.

The National Energy Board estimated Canada's established remaining recoverable reserves of conventional crude oil as of 31 December 1978 at 866.5 million cubic metres. Besides proven conventional oil reserves, it is estimated that 4.2 billion cubic metres of synthetic crude oil can be recovered from the oil sands by surface mining (improved mining methods could increase this figure to more than 12.7 billion cubic metres) and a further 31.8 billion cubic metres by 'in-situ' methods.

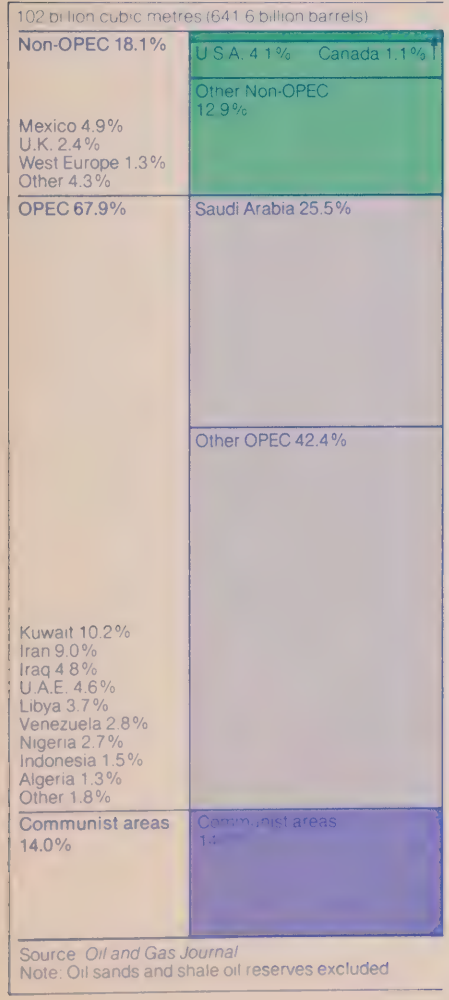
Canada also has significant oil resources in the frontier areas — the Arctic, the Mackenzie Delta, the Beaufort Sea, and off the east coast. Exploration off Newfoundland led to the discovery of the Hibernia oil field in August 1979.

Production from established conventional oil reserves in western Canada will decline substantially over the next decade. It is true that new discoveries of western conventional oil are expected and that new techniques to extract a larger proportion of the oil in the ground will make a growing contribution to supply. But together these two sources of additional supply are unlikely to be enough to compensate for the decline in conventional oil production.

Significant volumes of crude oil could be obtained from frontier sources by the mid-1990s, but it would be premature to count on those supplies at this time. During the late 1980s and early 1990s an increasing contribution to Canadian supply will be required from the oil sands.

Two oil sands plants are now producing commercially in western Canada. The first commercial-scale synthetic crude oil plant was the Suncor installation at Fort McMurray, which came on stream in 1967 and is now producing about 7200 m^3/day. The Syncrude project piped its first oil to Edmonton in August 1978, and it is expected to achieve its full authorized capacity of 21 000 m^3/day by 1983.

FIGURE 6: World crude oil reserves as estimated at 1 January 1980



Source *Oil and Gas Journal*
Note: Oil sands and shale oil reserves excluded

FIGURE 7: Forecast world oil supply and demand 1979-90 (million cubic metres/day)

	1979	1985	1990
World demand (excluding communist countries)			
IEA countries	6.6	7.0	7.2
Other countries	1.6	2.3	3.1
Total	8.2	9.3	10.3
World production			
Non-OPEC	3.2	4.1	4.5
OPEC	5.0	4.9	5.0
Net supply from communist countries	0.2	0.1	–0.2
Total	8.4	9.1	9.3
Stockbuild/(Shortfall)	0.2	(0.2)	(1.0)

Note: IEA countries are the twenty-one members of the International Energy Agency, which include the major free world industrialized nations.
Source: IEA projections as of May 1980

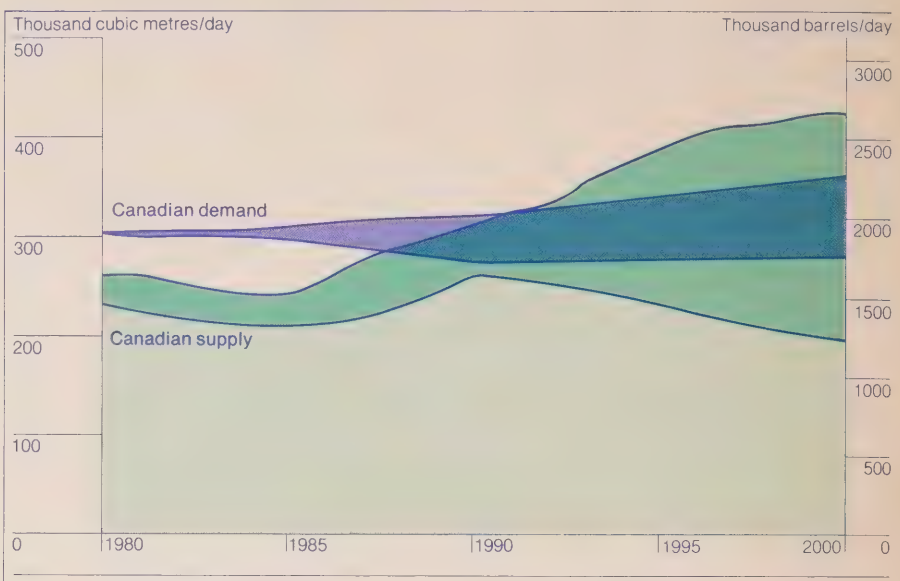
Further oil sands development is planned. Syncrude is considering increasing the capacity of its plant to 30 000 m^3/day. Suncor is proceeding with an expansion of its plant to a capacity of 9000 m^3/day. Two other projects are awaiting approval by the government of Alberta; the Alsands project, a venture headed by Shell Canada Resources with a planned capacity of 22 200 m^3/day, and another plant of similar size proposed by Imperial Oil at Cold Lake.

These plants are each expected to cost $7 to 8 billion. Plans for a further oil sands project are being developed jointly by Nova, An Alberta Corporation and Petro-Canada. Crude oil upgrading plants that will convert heavy crude oil from known reserves into a light, marketable crude oil are also receiving consideration.

The National Energy Board is conducting an inquiry into future energy supplies and requirements in Canada; the report is expected in 1981. Figure 8 shows the range of forecasts of supply and demand for Canadian oil presented to the Board as part of this inquiry. These forecasts show that Canada has the potential to be self-sufficient in crude oil.

The Ontario government has advocated a national target of achieving crude oil self-sufficiency for Canada by 1990, and that target has now been endorsed by the government of Canada. Attaining crude oil self-sufficiency will require much investment, because oil sands and frontier sources are expensive to tap. Further technological development is also necessary; for example, the technology for the recovery of in-situ reserves is not yet proven. Although large investments will be required, there is an urgent need to proceed with new oil sands development.

FIGURE 8: Canadian oil supply and demand outlook



Source: Range of estimates submitted to the National Energy Board, 1980

FIGURE 9: Major oil pipelines and oil fields in Canada

Oil in Ontario

Ontario accounts for 33 per cent of total Canadian oil consumption. Yet only a tiny fraction (less than one-half of 1 per cent of Ontario's consumption) is provided from Ontario's own production, which in 1979 was 253 m^3/day. About 91 per cent of Ontario s crude oil supply comes from western Canada through the Interprovincial Pipeline System (Figure 9). Much of the rest is supplied from United States crude oil exchanged for equal quantities of western Canadian crude oil delivered to refineries in the United States.

No imports of crude oil from outside North America were received in Ontario in the past year, although parts of eastern Ontario are supplied with refined petroleum products produced in part from foreign crude oil refined in Quebec.

Ontario has no direct access to large volumes of offshore crude oil supplies. The pipeline from Sarnia to Montreal is not yet able to handle a reversal of the easterly flow of crude oil, and the harbour facilities at Portland, Maine, and the pipeline from Portland to Montreal would require expansion to accommodate any significant additional volume of crude oil destined for Ontario.

Refineries in Ontario

The Ontario refineries that convert crude oil to petroleum products are located in three areas (Figure 10). More than half the province's refinery capacity is at Sarnia, with the remainder located in the Oakville-Mississauga area west of Toronto and at Nanticoke on Lake Erie.

FIGURE 10: Ontario's oil pipeline system

The principal products of Ontario refineries are shown in Figure 11. Motor gasoline accounts for more than one-third of refinery production. With the commissioning of the Petrosar plant at Sarnia in 1978 the share of petrochemical feedstocks, which are used to produce plastics, nylon, and so on, has grown. The refined products then move by truck, train, lake tanker, and pipeline throughout the province.

Ontario's refinery capacity has increased from 66 000 m^3/day in 1973 to 128 000 m^3/day in 1979 (Figure 12). Ontario has significantly more refining capacity than is required to meet the demand for oil products. The Texaco refinery at Port Credit is now idle except for petrochemical operations. The Petrosar refinery has adjusted its operations, reducing its requirements for crude oil and condensate feedstock at full capacity to about 17 000 m^3/day.

To minimize transportation costs, some 10 per cent of Ontario's requirement of refined petroleum products was brought into the province in 1979, primarily from Montreal into nearby eastern Ontario. In 1979 Ontario refineries produced 97 000 m^3/day, equivalent to 98 per cent of total Ontario consumption, but of this amount some was exported or sold in other provinces.

The surplus refinery capacity and the choice of processes has led to production of large volumes of residual heavy fuel oil, a by-product of the refinery process. The result has been severe competition between refineries and with natural gas in the industrial market, making it necessary to export substantial volumes of heavy fuel oil to the United States.

Two refineries at Sarnia, Petrosar and Suncor, will have modified their plants to lower their output of heavy fuel oil by the end of 1984. The changes, which may cost more than $500 million, will result in the production of a greater proportion of lighter products and therefore in reduced requirements of crude oil.

FIGURE 11: Ontario refinery production

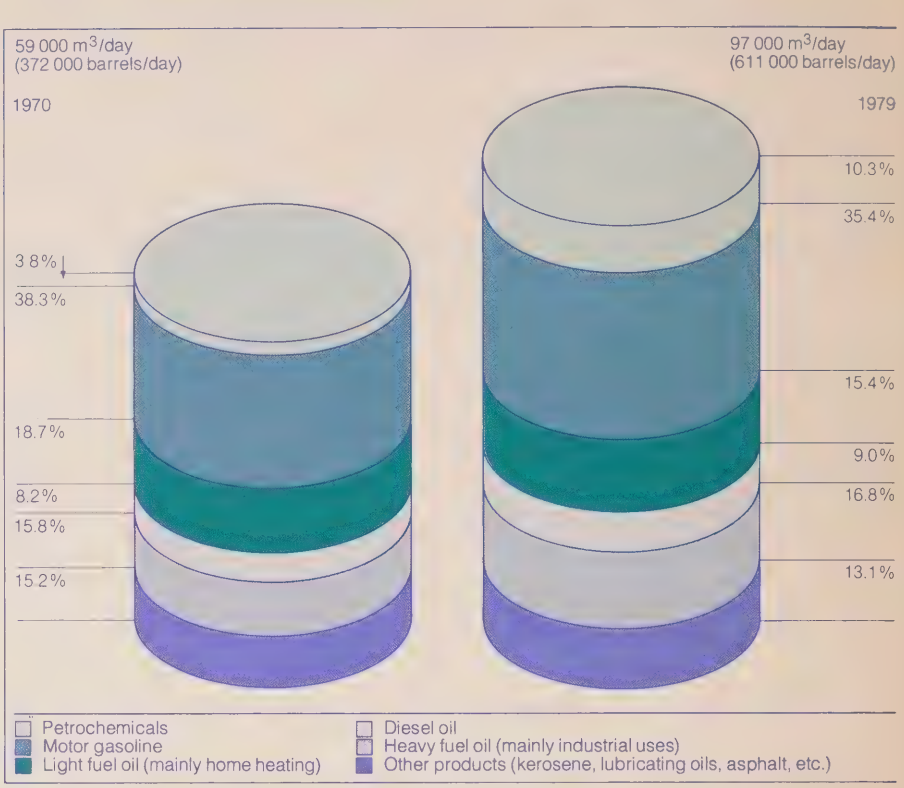


FIGURE 12: Ontario's crude oil refining capacity

	Cubic metres (m^3)/ calendar day	Barrels/ calendar day
Petrosar (Sarnia)	27 000	170 000
Imperial (Sarnia)	20 000	126 000
Texaco (Nanticoke)	15 000	95 000
Sunoco (Sarnia)	14 300	90 000
BP (Oakville)	12 700	80 000
Shell (Corunna)	11 800	74 000
Gulf (Clarkson)	12 600	79 000
Texaco (Port Credit)	7 600	48 000
Shell (Oakville)	7 000	44 000
Totals	128 000	806 000

Note: Texaco's Port Credit refinery is not operating at present.
Source: *Canadian Petroleum*, July 1980

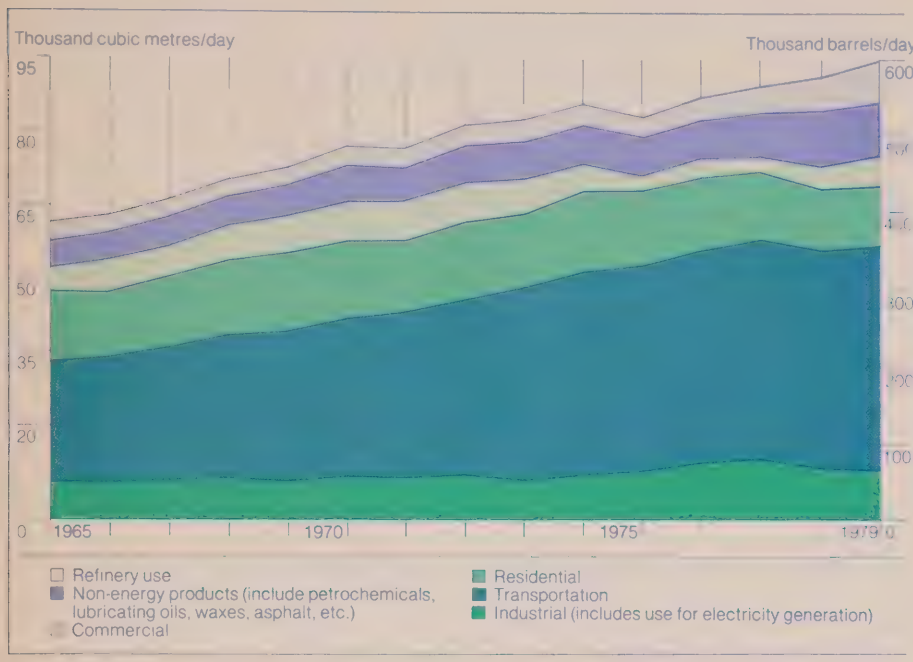
Consumption

Recent trends in the consumption of oil products in Ontario are presented in Figure 13. This diagram, like others that follow, shows the end use of energy products in the residential, commercial, industrial, and transportation markets.

About half of Ontario's oil consumption occurs in transportation. Residential or household uses consume 13 per cent, while industrial uses, including mining and manufacturing, consume 10 per cent. The commercial sector (institutions, office buildings, schools, street lighting, and water works) uses only 5 per cent of the province's oil. The remainder is accounted for by consumption of petrochemical feedstocks, asphalt, lubricating oils, and other non-energy products, as well as oil used for processing by the refineries themselves.

Following the price increases begun by OPEC in 1973, the consumption of oil products fell off in 1975, but it has since increased. Much of the increase is accounted for by greater use of petrochemical feedstocks and refinery fuel. Since 1970, consumption for transportation has been growing steadily, while the combined requirements of the industrial, commercial, and residential sectors have declined.

FIGURE 13: Oil consumption in Ontario

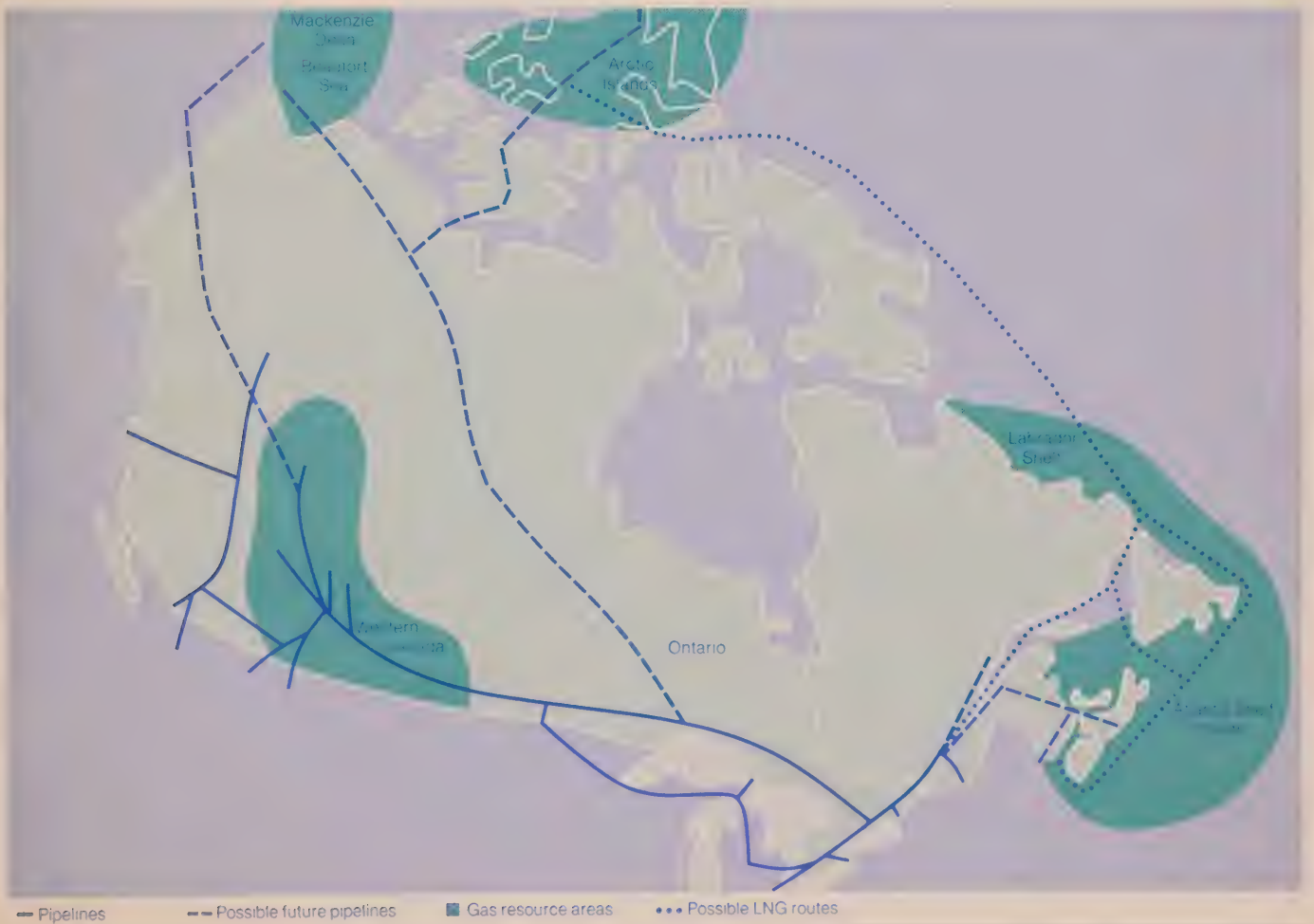


World natural gas production is of no immediate importance as a source of supply for Ontario because Canadian gas supplies are able to meet the country's needs. Most natural gas reserves in Canada are in Alberta, with smaller but significant quantities situated in British Columbia and Saskatchewan (Figure 14).

Significant reserves have also been found in the Arctic Islands and in the Mackenzie Delta/Beaufort Sea area, and there are prospects off the east coast of Canada. However, these reserves cannot be counted on until sufficient quantities are found to make their development and movement to market economic.

The National Energy Board's latest estimates of the ultimate potential of marketable natural gas in the conventional producing areas of Canada are as follows: British Columbia 595 billion cubic metres, Alberta 4.2 trillion cubic metres, Saskatchewan 85 billion cubic

FIGURE 14: Major natural gas pipelines and fields in Canada



metres, and the other provinces combined 28 billion cubic metres. To date, of this total about two-thirds has been found, and nearly one-quarter has been produced.

Total Canadian production of marketable natural gas in 1979 was about 77 billion cubic metres, of which nearly two-thirds was used in Canada and the rest exported to the United States.

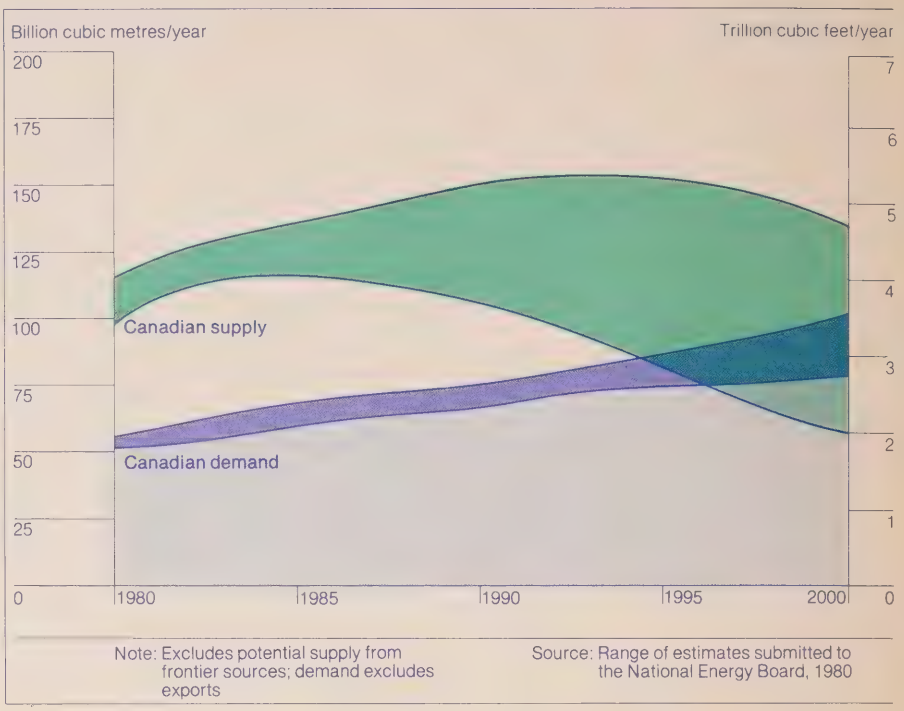
Just as important as the extent of reserves is the deliverability of the natural gas — the rate at which the gas could be produced with the current state of technology. Since the production volume of every well sooner or later begins to decline, new reserves must be found if the amount of gas being delivered is to grow or even remain constant.

From 1970 to 1975 more gas was being produced in Canada each year than was being added to reserves. This led to serious concern about the ability of reserves to meet future demand. Since 1975 prices have increased, exploration has expanded, and the addition of new reserves has exceeded production. Because demand has been less than forecast, there is now more natural gas in Canada available for sale than the domestic market can absorb.

The National Energy Board held extensive hearings in late 1978 on Canada's present and future gas supply and requirements. Recent submissions to the Board have confirmed its 1979 estimates that Canada can meet its own gas demand and authorized exports at least until the 1990s without reliance on supplies from frontier sources in northern Canada (Figure 15).

A series of hearings on market expansion in Quebec and the Maritime provinces and on gas exports recommended extension of service to Quebec City and increased gas exports to the United States. Since then the National Energy Program released in October 1980 has stated that the natural gas pipeline will be extended beyond Montreal to Quebec City and the Maritimes.

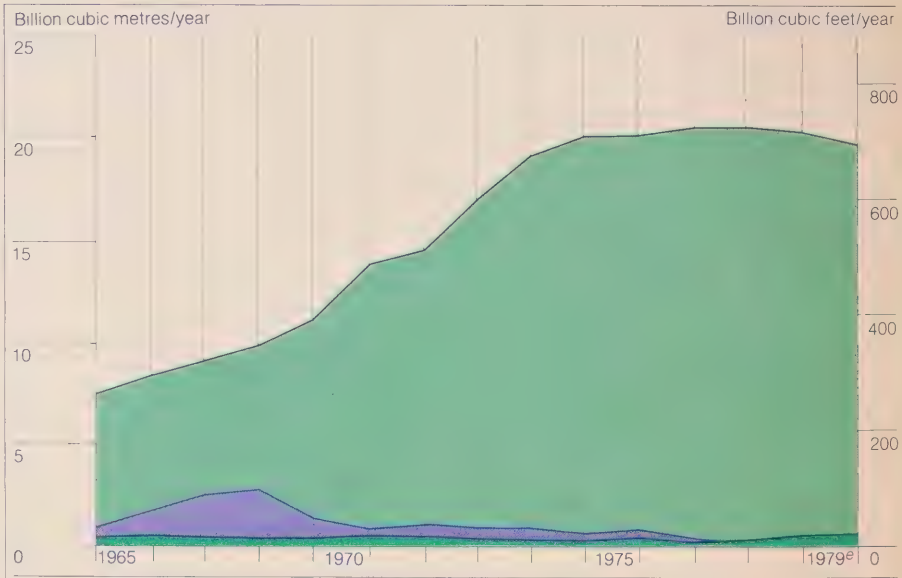
FIGURE 15: Canadian natural gas supply and demand outlook



Note: Excludes potential supply from frontier sources; demand excludes exports

Source: Range of estimates submitted to the National Energy Board, 1980

FIGURE 16: Natural gas supply in Ontario



e: Estimate; includes 150 and 225 million cubic metres of synthetic natural gas in 1978 and 1979 respectively

FIGURE 17: Natural gas pipelines in Ontario

Ontario's sources of supply

Almost all of Ontario's natural gas comes from western Canada, mainly Alberta (Figure 16). Ontario's domestic production of gas accounts for only about 1.5 per cent of Ontario's supply. Imports of natural gas from the United States peaked at about 23 per cent of total supply in 1968 but since then have been phased out.

Western Canadian gas is delivered to Ontario by TransCanada PipeLines through two pipeline systems, one of which runs through northern Ontario and the other south of the Great Lakes.

Some of the gas is piped to underground storage pools in southwestern Ontario. With new pools added in 1978 the province's total storage capacity has now reached 3.9 billion cubic metres, about two month's supply. This storage capability not only provides security of supply in emergencies but also allows distributors to purchase gas at a constant flow, meet winter peak demands, and minimize transportation cost.

In Ontario natural gas is distributed primarily by three companies: the Consumers' Gas Company, a division of Hiram Walker-Consumers Home Ltd, the largest, covering much of central and eastern Ontario; Union Gas Ltd, covering southwestern Ontario; and Northern and Central Gas Corporation Ltd. Much smaller areas are served by the Kingston Public Utilities Commission, the Corporation of the City of Kitchener, Natural Resource Gas Ltd, Inter-City Gas Corporation, and Wellandport Gas Company Ltd. Figure 17 shows the service areas of the distributors.

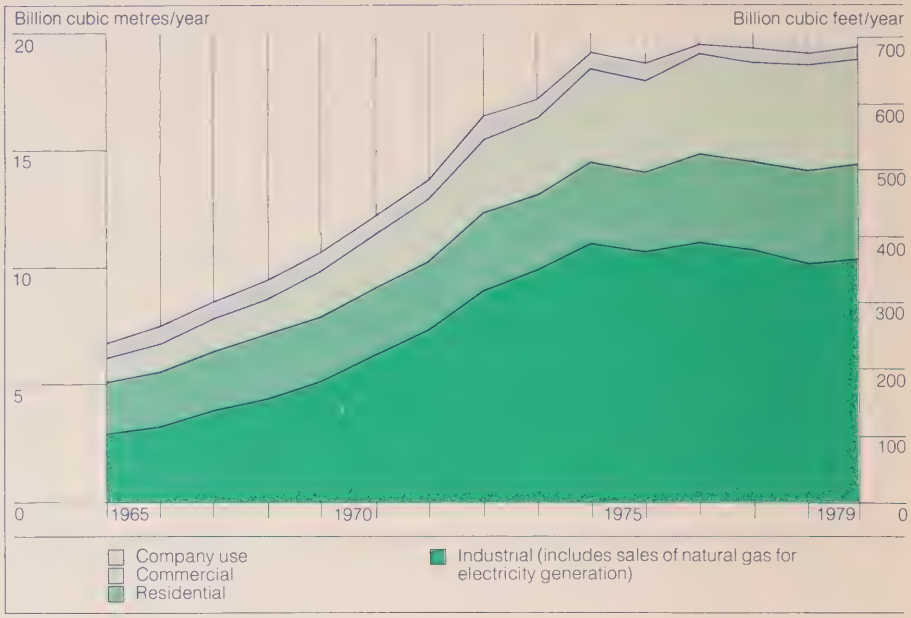
Ontario's consumption

Ontario uses three times as much natural gas now as it did in 1965. As Figure 18 shows, the province's gas consumption grew rapidly from 6.2 billion cubic metres in that year to 18.4 billion cubic metres in 1974. Consumption then rose slowly until 1979. Recently, the price advantage of natural gas and public concern over oil supplies for home heating have resulted in a marked increase of domestic conversions to natural gas. In 1979 natural gas consumption was 19.4 billion cubic metres.

Industrial uses (54 per cent at present) predominate, their share having risen from 48 per cent in 1965. The economic downturn and competition from heavy fuel oil have limited the further market penetration of natural gas in the industrial sector. That sector includes the natural gas used to generate electricity, which has declined quite rapidly in the last few years. Ontario Hydro has reduced its use of natural gas from 1.65 billion cubic metres in 1975 to 455 million cubic metres in 1979 and estimates it will use only 8 million cubic metres in 1981; this amount would be used mainly for igniting its coal furnaces.

The commercial sector's share now stands at 23 per cent, while the residential sector accounts for 20 per cent. In both the residential and commercial sectors, average per-customer use has been declining, mainly as a result of conservation efforts.

FIGURE 18: Natural gas consumption in Ontario



On the other hand the number of new residential customers that have converted from heating oil to natural gas has been most significant. About 8000 homes converted to natural gas in 1978; by 1979 conversions had risen to 24 000, and for 1980 it is estimated that 40 000 to 45 000 conversions will take place.

Ontario's production

Efforts to expand Ontario's natural gas production continue. They are focused on the Lake Erie region, where about two-thirds of the gas produced in Ontario is found. In 1979 a total of 232 oil and gas wells were drilled in Ontario, of which 67 were for exploration and 142 for development of proven reserves. In 1979, 292 million cubic metres of natural gas were produced in Ontario.

In 1977 the Petrosar refinery in Sarnia began producing 'synthetic natural gas' (SNG) as one of its outputs. Production has risen to 225 million cubic metres, or nearly as much as is coming from Ontario wells. However, because it is produced as a by-product of crude oil refining, it costs almost twice as much as western Canadian natural gas delivered to Toronto. Approval has been given by the National Energy Board to export this high-cost gas to the United States.

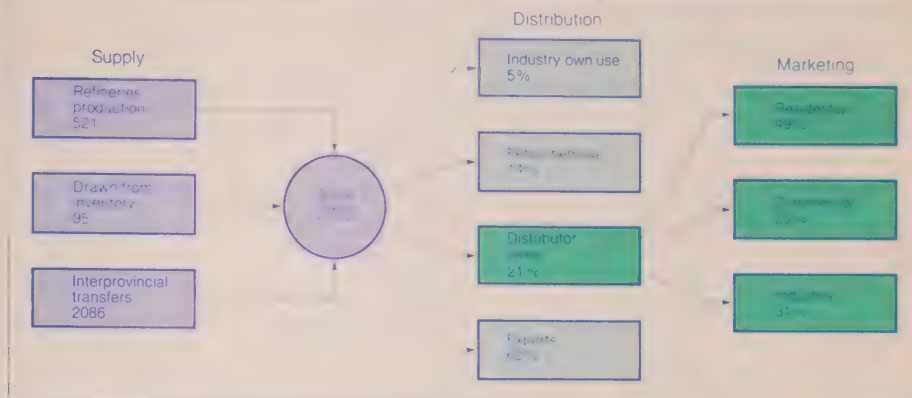
New transportation systems

By the 1990s the supplies of gas in the Mackenzie Delta/Beaufort Sea area, in the Arctic Islands, and possibly in other frontier areas may be required to meet Canadian demand (Figure 15). Because of the long lead times needed to plan, finance, and construct frontier pipeline or liquefied natural gas (LNG) facilities, several major proposals are under active consideration; these have been included in Figure 14.

At the present time all estimates of the ultimate reserve potential in the frontier regions of Canada must be regarded as highly speculative. The 1979 National Energy Board report on natural gas reserves credited the Mackenzie Delta/Beaufort Sea area with 150 billion cubic metres of established reserves and the Arctic Islands with 261 billion cubic metres of established reserves. Recent discoveries in both areas will add to these reserves.

Polar Gas, a joint venture in which the Ontario Energy Corporation is a participant, has been studying the feasibility of building a pipeline from the Arctic Islands to connect with the TransCanada PipeLines system at Longlac in northern Ontario. Polar Gas applied to the National Energy Board for a direct route in 1978. A recent announcement by Polar Gas stated that a new application would be made in 1981 for a combined system to deliver both Mackenzie Delta and Arctic Island reserves via a 'Y' pipeline to connect with the TransCanada system in northern Ontario.

FIGURE 19: Propane supply and demand in Ontario, 1979 (thousand cubic metres)



Note: Total supply is net of 54 000 cubic metres attributed to losses and adjustments.
Source: National Energy Board and Dome Petroleum, 1980

The National Energy Board has approved extension of the TransCanada PipeLines system from Montreal to Quebec City but denied an application by Q. & M. Pipelines to extend the system further to New Brunswick and Nova Scotia. Construction of the Quebec lateral line may commence as early as 1981. In the National Energy Program the federal government declared its intention to extend the pipeline to the Maritime provinces.

An application has been made to the National Energy Board and the Department of Indian Affairs and Northern Development by Petro-Canada and Nova, An Alberta Corporation to ship LNG from Melville Island in the high Arctic to markets in eastern Canada and the United States.

Propane and butane

Propane and butane are petroleum gases which can be liquefied at relatively low pressure at atmospheric temperatures. Thus they can be conveniently stored and transported as liquids in light pressure tanks. When the pressure is reduced the liquid boils, releasing a clean-burning gaseous fuel. They can be used in a great variety of applications including gasoline blending, heating, cooling, and crop-drying. Attention has recently been focused by tax incentives and demonstration projects in Ontario on the use of propane as a transportation fuel to replace gasoline. Propane and butane are used as feedstocks for the refining and petrochemical industries and are sometimes injected into reservoirs to enhance oil recovery (Figure 19).

FIGURE 20: Bulk propane distribution terminals in Ontario

1 - MOOSONEE
2 - KENORA
3 - VERMILION BAY
4 - DRYDEN
5 - LONGLAC
6 - IGNACE
7 - HEARST
8 - FORT FRANCES
9 - MANITOUWADGE
10 - THUNDER BAY
11 - WAWA
12 - PORCUPINE
13 - SAULT STE MARIE
14 - SUDBURY
15 - BLIND RIVER
16 - NORTH BAY
17 - PARRY SOUND
18 - PEMBROKE
19 - HUNTSVILLE
20 - BANCROFT
21 - BALA
22 - HAWKESBURY
23 - OTTAWA
24 - CARLETON PLACE
25 - CORNWALL
26 - WASHAGO
27 - FENELON FALLS
28 - NEWBORO
29 - PRESCOTT
30 - PETERBOROUGH
31 - OWEN SOUND
32 - ALLISTON
33 - BARRIE
34 - KINGSTON
35 - BELLEVILLE
36 - WALKERTON
37 - CONCORD
38 - MARKHAM
39 - WESTON
40 - WHITBY
41 - GODERICH
42 - BLYTH
43 - GUELPH
44 - GRAND BEND
45 - STRATFORD
46 - PUTNAM
47 - MILTON
48 - SARNIA
49 - STRATHROY
50 - SMITHVILLE
51 - AYLMER
52 - CHATHAM
53 - SIMCOE
54 - WINDSOR
55 - ESSEX
56 - CAYUGA

Source: Dome Petroleum, 1980

Propane and butane are produced in Canada from gas plants and oil refineries. Gas plants, which extract propane and butane from natural gas, accounted for more than three-quarters of the total Canadian production of about 35 000 cubic metres a day in 1979. Oil refineries accounted for the rest. About 62 per cent of Canadian production was exported, industrial uses accounted for about 26 per cent, and residential uses for the remaining 12 per cent.

In 1979 Ontario used about one million cubic metres of propane for energy and as a petrochemical feedstock. There are already more than fifty bulk propane distribution terminals in Ontario and several hundred retail outlets (Figure 20).

Propane distributing companies plan to establish at least one hundred vehicle fuelling stations to serve local fleets, and the number of propane vehicles on the road is expected to grow to at least 40 000 by 1985.

To stimulate the increased use of propane for transportation, the Ontario government removed the sales tax from licensed vehicles powered exclusively by propane and exempted it from the Ontario gasoline retail taxes.

The unpredictability of petroleum supplies and prices has fostered a renewed interest in coal. Proven and economically recoverable coal reserves in Canada exceed 25 billion tonnes. Total recoverable Canadian reserves may ultimately exceed 200 billion tonnes

In 1979 Canadian production was 33.0 million tonnes of all types of coal. Of this amount about 13.6 million tonnes were exported, primarily to Japan. However, imports in 1979 amounted to 17.4 million tonnes, making Canada a net importer.

Electrical generation accounted for more than 72 per cent of Canada's coal consumption. Metallurgical applications (to make iron and steel) accounted for an additional 23 per cent, and the remainder found other industrial uses.

Ontario accounts for about 51 per cent of total Canadian coal consumption and for virtually all Canadian coal imports. More details of Ontario's coal use can be found in the recent Ontario government publication *Coal in Ontario*.

Ontario's supply

Ontario produces no coal but depends on the Appalachian region of the United States, western Canada, and the Maritimes for supplies. In 1979 about 87 per cent of the coal consumed in Ontario came from the United States; the remaining 13 per cent came from Canadian sources, primarily in western Canada.

Canadian coal has always fulfilled only a small part of Ontario's coal needs (Figure 21). That is because transportation costs make western Canadian coal shipped to Ontario 40 to 50 per cent more expensive than Appalachian coal on a heat-content basis. The production facilities for Nova Scotian coal, the quality of which is similar to that of American coal, are limited. Ontario Hydro is expanding its use of western Canadian coal to diversify its supply sources and to obtain low-sulphur grades that can be blended with American coal.

Deliveries of western Canadian coal began in 1978 after the completion of the new Thunder Bay coal terminal. Designed to move 5.4 million tonnes annually, with an initial annual throughput of 2.7 million tonnes and a stockpile capacity of 1.1 million tonnes, the terminal links western rail transportation with Great Lakes vessels.

FIGURE 21: Coal supply in Ontario

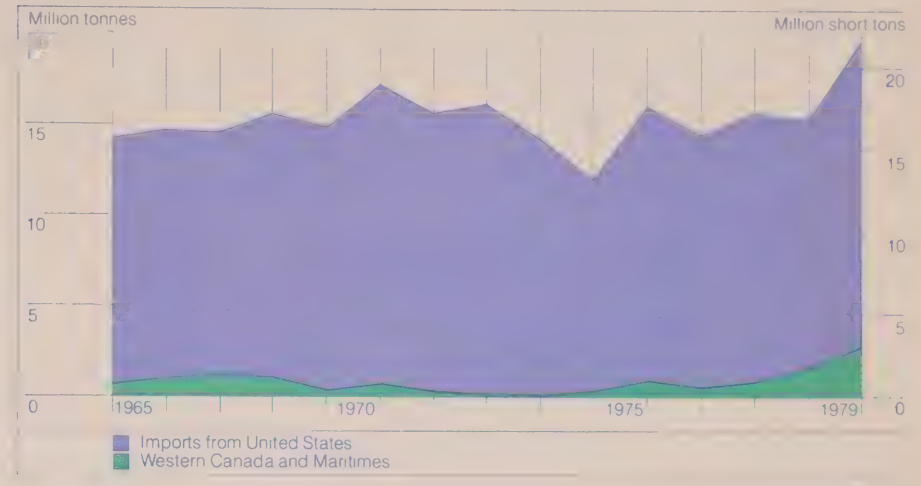
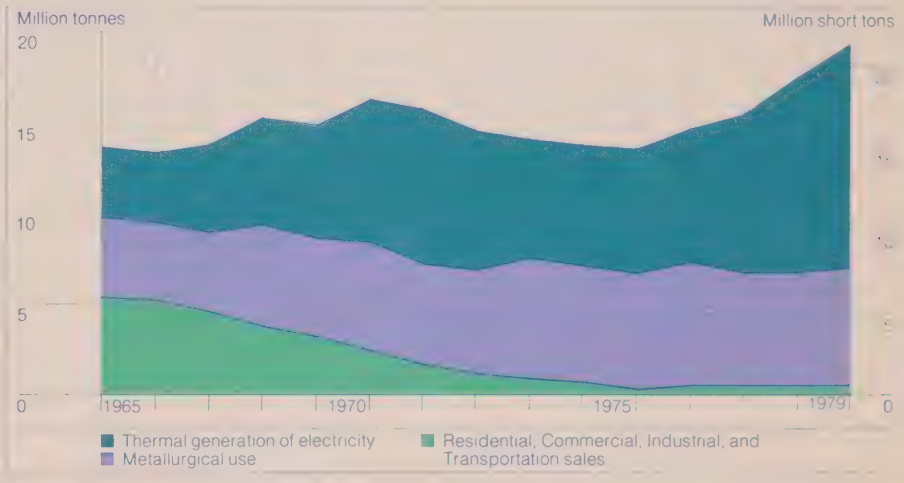


FIGURE 22: Coal consumption in Ontario



The other significant use for coal in Ontario is as coke for making steel. The three largest steel companies in Ontario and Canada — Algoma, Dofasco, and Stelco — import almost all their coking coal from the United States.

Of an estimated import volume of 6.9 million tonnes, Stelco accounts for about half. In addition, that company has signed a five-year contract for 500 000 tonnes a year of metallurgical coal from Nova Scotia's Lingan mine. Deliveries of only half the contract level are being received. Dofasco is reported to be investigating several coal properties in western and eastern Canada in order to secure additional supplies.

Renewed interest has been shown in Ontario's only known source of coal, the Onakawana lignite deposit, discussed below under Alternative Energy Supplies.

Ontario's consumption

As Figure 22 shows, almost all coal consumed in Ontario is used either in steel making or in generating electricity. The residential, commercial, industrial (apart from steel manufacturing), and transportation sectors combined account for only about 3 per cent of the coal used in Ontario, down markedly from their 39 per cent share in 1965. Metallurgical coal consumption as a proportion of total coal consumption has risen from 32 per cent (4.3 million tonnes) to 41 per cent (7.2 million tonnes) today. However, for a variety of reasons such as declining automobile production and the current recession, Ontario's steel-makers continue to experience slower growth in product demand, which is reflected in a lower growth rate in their coal requirements.

The use of coal in generating electricity has doubled since 1965, increasing its share of total coal consumption from 29 per cent to 56 per cent in 1979.

Water-power

Water-power, Ontario's major developed renewable energy source, continues to be an important, although in relative terms declining, primary energy source for the generation of electricity in Ontario. Ontario Hydro and several smaller utility and industrial companies in the province now have 7151 megawatts (MW) of dependable hydroelectric capacity, with an average annual capability of 4411 MW.

Undeveloped hydroelectric resources in Ontario total approximately 3750 MW in average annual capacity. These undeveloped hydraulic sites, whose peak capacity is more than twice their combined average annual capacity, could be particularly valuable in meeting growth in the peak load.

The most significant potential—up to 2450 MW average annual capacity—lies in northerly flowing rivers, namely the Severn and the Albany (including diversions from other river systems). At this time development of these river systems is not under active consideration because of their distance from markets, the high development costs, and the concerns expressed by native and environmental groups.

Approximately 500 MW of the undeveloped potential is dispersed among many small sites, each having an average annual capability of less than 10 MW. There has recently been a renewal in private sector interest about small hydro developments, and a number of these small sites are now being considered.

A program for the assessment of expanded hydroelectric generation, including ten new developments and seven extensions or redevelopments of present stations, was announced jointly by the Ministry of Energy and Ontario Hydro in August 1978.

If all sites prove feasible and all necessary approvals are obtained, construction on the seventeen projects could begin as early as 1988 and could be completed by 1995. The actual timing of this program, however, will be considered in relation to both the need for additional capacity to meet growth in demand and the advantages of using an indigenous, renewable energy resource instead of importing fuel.

The total average annual capacity of the seventeen projects would be over 500 MW, and the peak capacity would be approximately 2000 MW. The provincial government has established a target of an additional 2000 MW (peak) of hydraulic capacity in Ontario by 1995.

Uranium

Canada possesses about one-fifth of the western world's estimated uranium resources and is expected to play an important role in meeting the world's projected uranium requirements.

To safeguard Canadian interests, the federal government's uranium policy requires enough uranium to be reserved for domestic use to enable each existing and planned Canadian reactor to operate at an average annual capacity of 80 per cent for thirty years from its in-service date.

In 1979 Canada produced about 6800 tonnes of uranium, two-thirds in Ontario and the rest in Saskatchewan. Exports, which took place under Canadian policies directed at ensuring their application to peaceful purposes, accounted for 86 per cent of production.

In 1979 it was estimated that at prices of up to $175 a kilogram Canada had uranium reserves of 537 000 tonnes, composed of 80 000 tonnes measured, 155 000 tonnes indicated, and 302 000 tonnes inferred. Because the resource estimates in the latter two categories are less reliable than that in the measured category, they are adjusted by weighting factors in order to arrive at an 'adjusted reserve' against which domestic requirements can be compared. The Canadian adjusted reserve is calculated as 415 400 tonnes.

Long-term uranium requirements for Ontario Hydro's existing and planned reactors amount to about 20 per cent of Canada's total adjusted reserve. Beyond their existing commitments and their required domestic allocations, therefore, Canadian uranium producers have almost half of the adjusted reserve available for future export or domestic needs.

Ontario's 1979 uranium consumption was about 690 tonnes, virtually all of it supplied from within the province itself. In February 1978 the Ontario government approved the purchase by Ontario Hydro of nearly 91 000 tonnes of uranium from the Elliot Lake area for the period from 1980 to 2020. One contract, with Denison Mines Ltd, calls for the delivery of 57 000 tonnes between 1980 and 2011, and the other, with Preston Mines Ltd, is for 33 000 tonnes between 1984 and 2020. These contracts secure supplies for Ontario Hydro's nuclear program.

Electricity

Electricity is a secondary source of energy manufactured from such primary sources as coal, water-power, uranium, oil, and natural gas. Figure 23 shows that the primary energy composition of Ontario electricity has changed dramatically over the last decade and a half.

Since 1965 Ontario's electrical energy supply has more than doubled. In that time, however, the output of Ontario's traditionally predominant source of electricity, water-power (hence 'hydraulic' or 'hydro' electricity), has remained relatively constant, so that the rivers and dams that provided 63 per cent of Ontario's electrical power in 1965 now account for only 36 per cent of the total.

In 1965 less than one-quarter of Ontario's electricity was thermally generated, from coal, oil, or natural gas. By 1979 conventional thermal output had tripled, so that coal (with small amounts from oil and natural gas) produced about 29 per cent of the province's electrical supply. Ontario Hydro recently announced almost complete phasing out of natural gas for the generation of electricity.

In the 1970s the most important development was the introduction of nuclear-powered (uranium) thermal generation. Uranium-based electricity has expanded rapidly in the last several years until in 1979 about 29 per cent of the province's electrical supply was produced by that means.

The final component of Ontario's electrical supply consists of purchases from Quebec, Manitoba, and the United States. In absolute terms these imports have remained generally constant since 1965, but in relative terms they have declined from 10 to 7 per cent.

Purchases continue for reasons of economy despite Ontario Hydro's surplus generating capacity of between 2000 and 3000 MW. Occasionally a neighbouring electrical utility can produce more power from an efficient generating station than its system requires. If at the same time a temporary increase in demand occurs in Ontario, it may be cheaper for Ontario Hydro to purchase that electricity than to start up additional higher-cost generating capacity.

At the same time, Ontario s surplus capacity has been put to work generating revenue from electrical exports. Since 1978 electrical exports have exceeded imports. In 1979 Ontario Hydro earned net revenues of $155 million on export sales of $345 million.

Generally speaking, water-power, coal, and uranium each contribute to the production of about one-third of Ontario's electricity. This means that about two-thirds of the province's electricity is produced from Ontario-based resources: water-power and uranium.

In 1979 Ontario Hydro generated 94 per cent of the electricity produced in Ontario. The rest was produced by a number of privately owned electrical utilities and several larger industries supplying much of their own needs.

The generating capacity of Ontario Hydro s system is outlined in Figure 24.

FIGURE 23: Electricity supply in Ontario

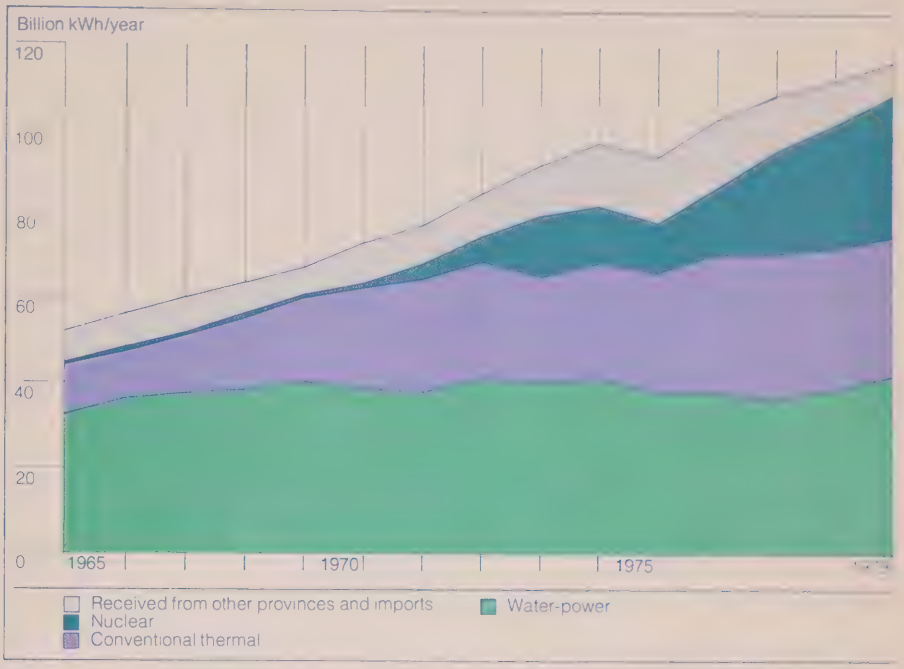


FIGURE 24: Ontario Hydro generating capacity, December 1980

	In-service dependable capacity megawatts*	Proportion of system	Planned additional capacity by 1995 megawatts	Proportion of expanded system*
Hydraulic generating stations				
East System (Rivers: Niagara, Welland Canal, St Lawrence, Ottawa, Madawaska, Abitibi, Mississagi, Mattagami, Montreal, etc.)	5 899		Program to add 2000 MW under development	
West System (Rivers: Nipigon, English, Kaministikwia, Winnipeg, Aquasabon, etc.)	589			
Total hydraulic generation	6 488	29.1%		20 3%
Nuclear generating stations				
Douglas Point (AECL, Kincardine)	206			
Bruce (Kincardine)	2 960		3 076	
Darlington (Newcastle)	—		3 400	
Nuclear Power Demonstration (AECL, Rolphton)	22			
Pickering	2 060		2 064	
Total nuclear generation	5 248	23.5%	8 540	43.4%
Conventional thermal generating stations				
Atikokan (Phase I)			400	
†J. Clark Keith (Windsor)			256	
†Richard L. Hearn (Toronto)	587			
Lakeview (Mississauga)	2 296			
Lambton (Courtright)	2 100			
†Lennox (Kingston)	1 116			
Combustion Turbines	445			
Nanticoke	3 920			
Thunder Bay	100		310	
Combustion Turbines and Diesel Electric	29			
Wesleyville (Port Hope)	—		construction stopped	
Total thermal generation	10 593	47.4%	966	36 3%
Grand total	22 329		9 506	

*Excludes mothballed and reserve units
†Total dependable capacity for mothballed and reserve units at these locations is 1829 MW
Source: Ontario Hydro estimates

The generating stations and transmission lines are shown in Figure 25.

Nuclear generation has provided a new and rapidly growing source of efficient base-load supply, supplementing the base-load hydraulic stations on the system. The remaining hydraulic stations and some fossil-fuelled generating stations handle the peak loads that occur both daily and seasonally. The remaining thermal generating stations are designed for intermediate duty.

In March 1980 Ontario Hydro announced a new schedule of in-service dates for its approved generating stations. Under the new schedule the two units of the Thunder Bay station will come into service in 1981; the four units of Pickering B between 1982 and 1984; the four units of Bruce B between 1983 and 1987; the two units of Atikokan in 1984 and 1988; and the four units of Darlington between 1988 and 1991. Construction on the oil-fired Wesleyville station has been stopped and the equipment stored on site.

Ontario Hydro distributes electricity in two ways (Figure 26). About 61 per cent of its production is sold wholesale to the province's more than 300 municipal utilities, which in turn service nearly two million urban retail customers. Of the remaining 39 per cent sold direct by Ontario Hydro, about one-third is sold to more than one hundred large industrial customers, another third is retailed to about three-quarters of a million rural customers not served by municipal electrical utilities, and the remainder is exported.

Although the electrical supply picture has been transformed since 1965, the pattern of consumption has scarcely changed at all (Figure 27); consumption in all sectors has simply doubled. Commercial and industrial uses still account for about two-thirds of total sales, and residential and farm uses remain just over one-quarter.

Historically the demand for electricity in Ontario has grown at about 7 per cent annually. But since 1974 the rate of growth has declined to an average of 3.9 per cent annually. Ontario Hydro's most recent load forecast, released in January 1981, predicted an annual average growth in demand of 3.1 per cent to the end of the century.

FIGURE 25: Ontario Hydro System

Nuclear power

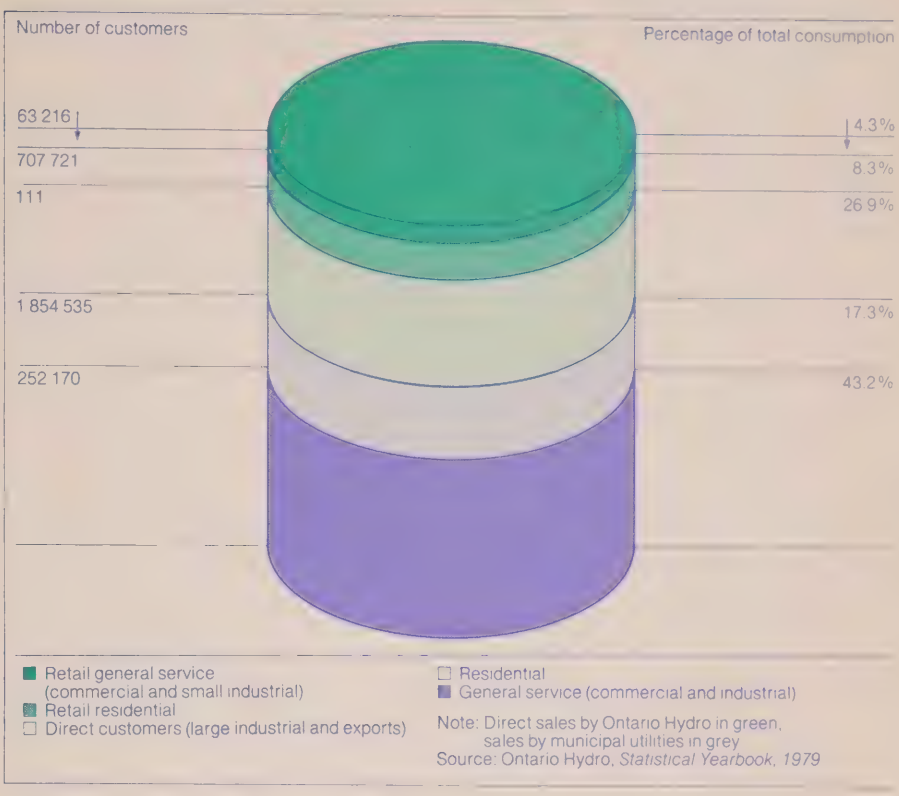
There are four operating nuclear generating stations in Ontario: at Pickering, at Bruce and Douglas Point in the Bruce Nuclear Development, and at the Nuclear Demonstration Project near Rolphton, northwest of Ottawa (Figure 25).

Lifetime performance statistics to the end of 1979 for the 104 reactors in the world whose capacity exceeded 500 MW showed that the Pickering and Bruce stations took six of the top seven placings. Pickering 2 achieved the best lifetime capacity factor of any such station in the world. Pickering's total unit energy cost (capital plus operating) was 11.2 mills per kilowatt hour in 1979 (a mill is one-tenth of a cent), compared to a 16 mills per kilowatt hour fuelling cost alone for producing electricity under similar conditions at one of Ontario Hydro s more efficient coal-fired plants, such as Lambton Generating Station near Sarnia.

Bruce A Unit 4 was declared in service on 18 January 1979, marking the completion of the four-unit 2960 MW station, one of the world's largest.

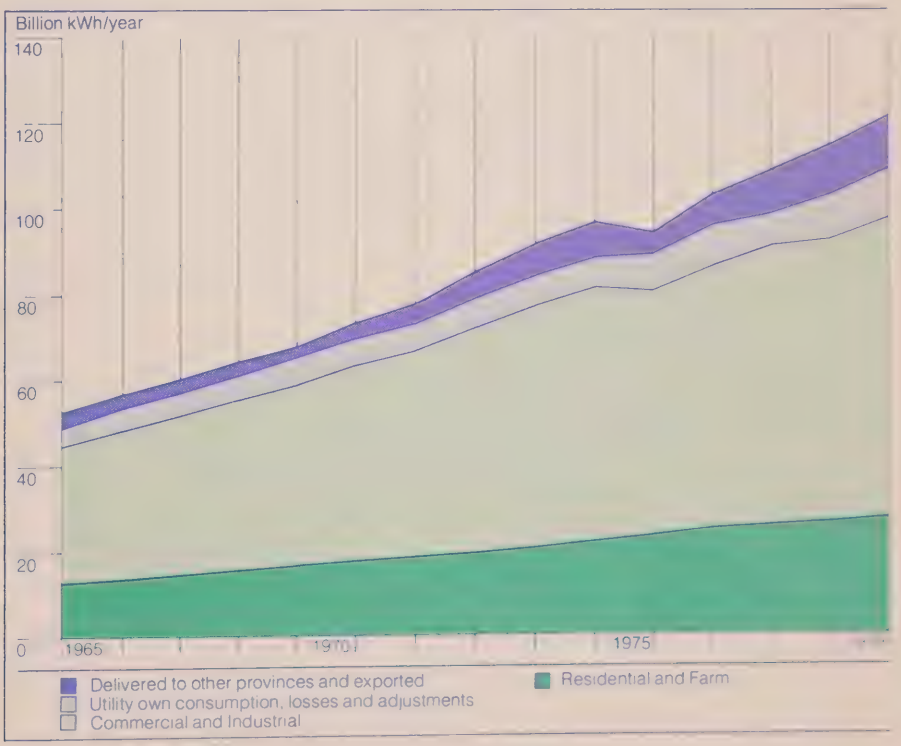
Electrical production from Ontario Hydro's nuclear units displaced 13 million tonnes of coal in 1980; cumulatively to date nuclear production has displaced about 70 million tonnes of coal.

FIGURE 26: Ontario Hydro sales



Note: Direct sales by Ontario Hydro in green, sales by municipal utilities in grey
Source: Ontario Hydro, *Statistical Yearbook, 1979*

FIGURE 27: Ontario electricity consumption



Energy prices

After 1973 the wholesale price of energy in Ontario increased sharply and in some cases quadrupled by 1980. At the retail level fuel prices have not increased as dramatically as that, because processing and distribution costs and, in the case of gasoline, taxes have not risen as sharply.

The picture seen by the Ontario consumer is suggested in Figure 28, in which the Toronto Consumer Price Index (CPI) is compared with indexes for the costs of residential heating oil, natural gas, electricity, and gasoline and for personal disposable income since 1965. Through the 1960s the energy price indexes lagged behind the CPI; natural gas prices in fact did not change at all until 1973. That was also the year the heating oil index clearly passed the CPI.

Since 1973 all four energy price indexes have risen more than the CPI. Instead of holding down the over-all price increase, energy is now driving it upwards.

A similar pattern emerges when growth in incomes is compared with the increases in energy prices. In particular, home heating oil and natural gas prices have increased more rapidly than incomes since 1973. This suggests that unless homeowners have taken measures to reduce their consumption, they will be devoting a larger share of their household budget to paying for energy.

Figure 28 shows only proportional increases, not the prices themselves. In December 1980 representative homeowner costs for the fuels in Toronto were as follows: home heating oil 19 cents/litre, regular leaded gasoline 30 cents/litre, regular unleaded gasoline 32 cents/litre, natural gas $4.05/thousand cubic feet, and electricity 3.3 cents/kWh.

Figure 29 compares wholesale energy prices in Ontario since 1965 based on the amount of heat energy each represents. For crude oil the increase came suddenly in 1974 (a year later for coal and natural gas), whereas for electricity the increases were more gradual, starting in the 1960s. Moreover, between 1973 and 1979 the prices of oil, natural gas, and coal have more than tripled, whereas electricity prices have approximately doubled.

FIGURE 28: CPI, personal disposable income, and energy indexes

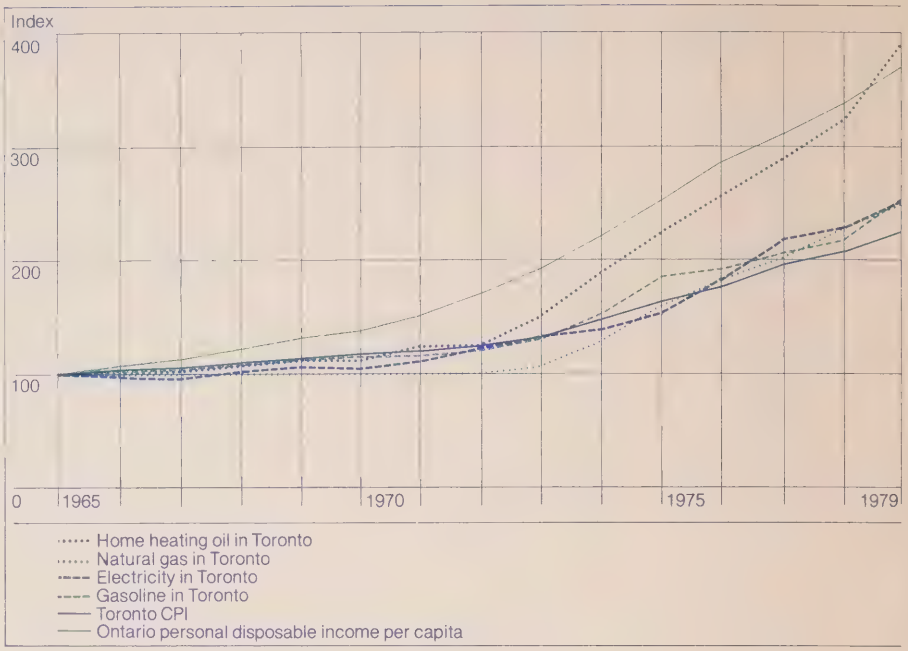
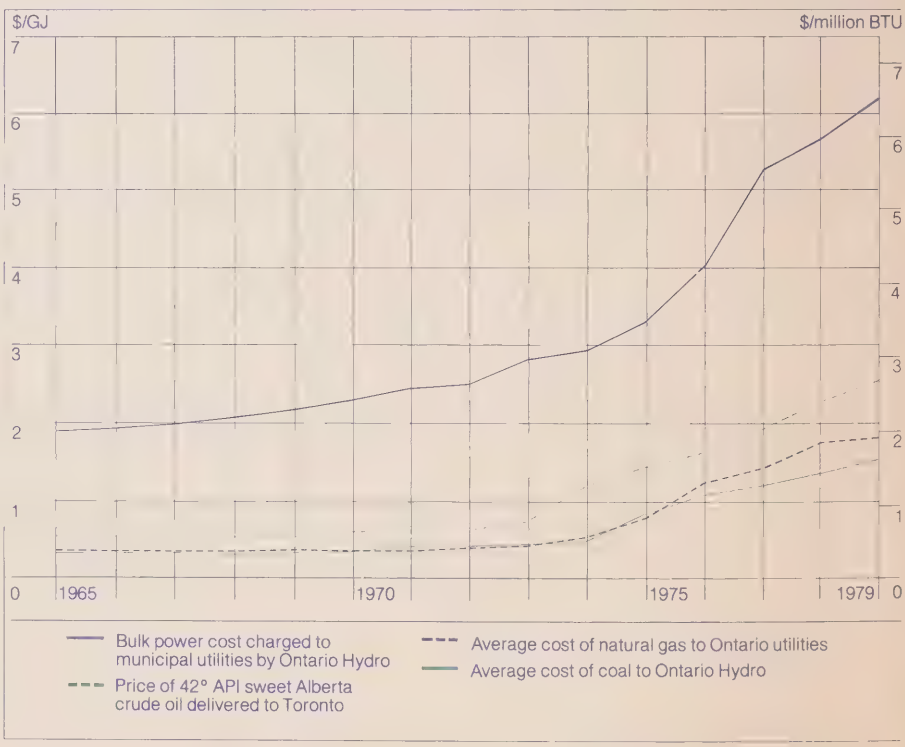


FIGURE 29: Wholesale energy prices in Ontario



Electricity is more expensive in terms of energy content than the other three forms of energy, because it is a secondary form of energy, itself created from primary forms. In many applications, however, its use is more efficient, which tends to narrow the price differences. Although Canadians today pay much lower prices for crude oil than people of other nations, in many parts of Ontario electricity is already cheaper than oil for home heating.

In November 1979 a survey of twenty-five Ontario communities showed that electric heat was more expensive than heating oil in twenty; by November 1980, one year later, only four of the same twenty-five communities were paying more for electric heat than for heating oil. Where natural gas is available it continues to be less expensive than electricity. However, as the prices of natural gas and Canadian oil move higher, electricity should become a more attractive form of energy for many users (see the forecast in Figure 56).

Not all parts of Canada and the United States have been affected equally by rising energy prices. For instance, Ontario communities pay less for electricity than most other North American cities (Figure 30). The Ontario Hydro Rural Retail Rate is significantly higher than the Toronto residential rate because of the higher cost of distributing electricity to more widely dispersed customers.

A policy to reduce the differential between Ontario Hydro's rural residential electricity rates and the average rate charged by municipal utilities has been adopted by the Ontario government.

When it comes to industrial electricity rates, Ontario is one of the more fortunate provinces. Its rates are much lower than those in most other industrialized parts of the world (Figure 31).

FIGURE 30: Residential electrical bills – July 1980

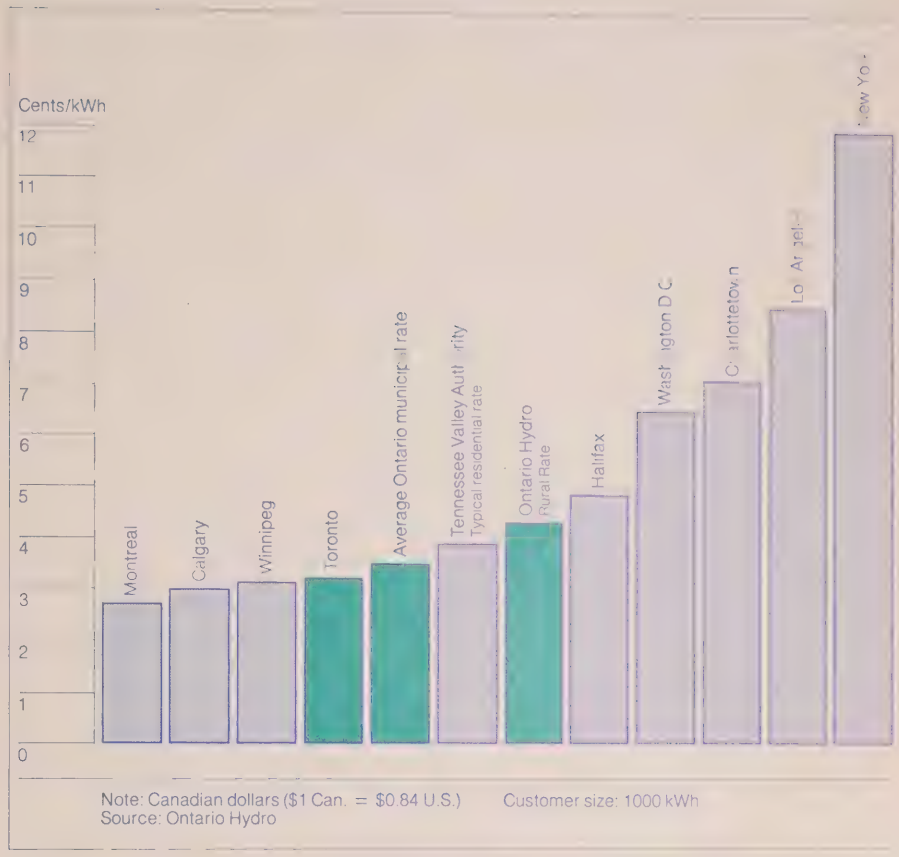
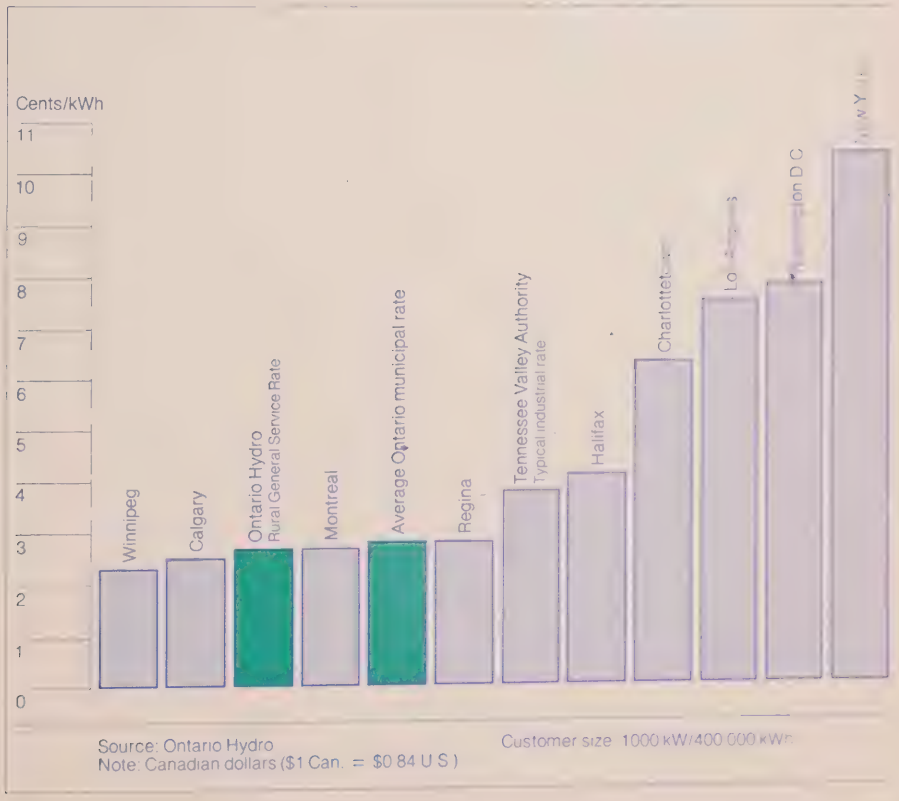


FIGURE 31: Industrial electricity rates – July 1980



Revenue distribution

Where does the consumer's energy dollar go? In Toronto, federal and provincial taxes account for about one-third of the cost of gasoline (Figure 32). The cost of crude oil accounts for 45 per cent, and the remainder, about 25 per cent, pays for refining and marketing costs, including dealers' margins.

As to the cost of crude oil and natural gas (Figure 33), in 1979 the governments of the producing provinces and the federal government captured nearly 60 per cent of production income (production revenues less operating costs).

Although industry's proportional share has declined from 65 per cent in 1973 to about 41 per cent in 1979, industry's dollar share has increased substantially to about $5 billion, three times the level in 1973. The major recipients of production income, about half, are the governments of the producing provinces, which now receive nearly $5.5 billion, up from about $700 million in 1973. Most of these revenues accrue to the Alberta government.

According to the National Energy Program, of total oil and natural gas production revenues during 1980-3 of about $90 billion, the producing provinces will get 43 per cent, industry 33 per cent, and the federal government 24 per cent. All three will receive increasing revenues over the period. This estimate reflects certain assumptions on the level and price of natural gas export sales, includes land bonus payments in the provincial share, and excludes the major part of the revenues from the Petroleum Compensation Charge. The Alberta government disputes this presentation of future revenue shares and the inclusion of land bonus payments in the provincial share.

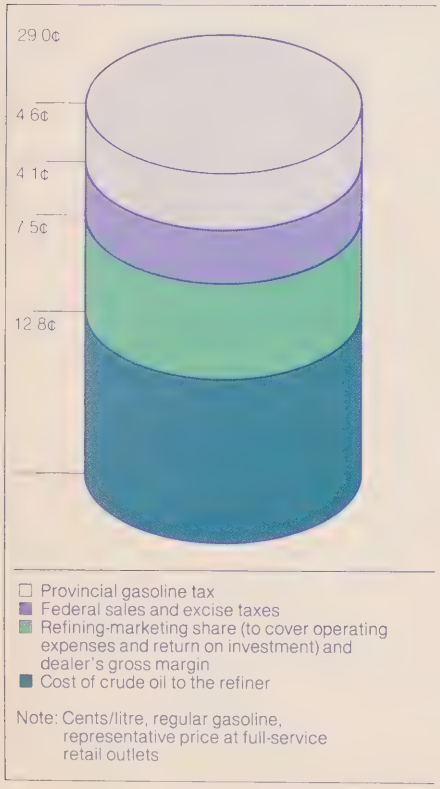
Electricity is sold at wholesale by Ontario Hydro to the municipal electric utilities and directly at retail to its rural and industrial customers. Any net income is reinvested in the corporation for system expansion, to retire debt, for contingencies, or to reduce the level of rate increases that would otherwise be required.

Unlike crude oil, gasoline, and natural gas, there are no corporate income taxes included in the price of electricity, nor is there any distribution of dividends to shareholders.

World oil prices

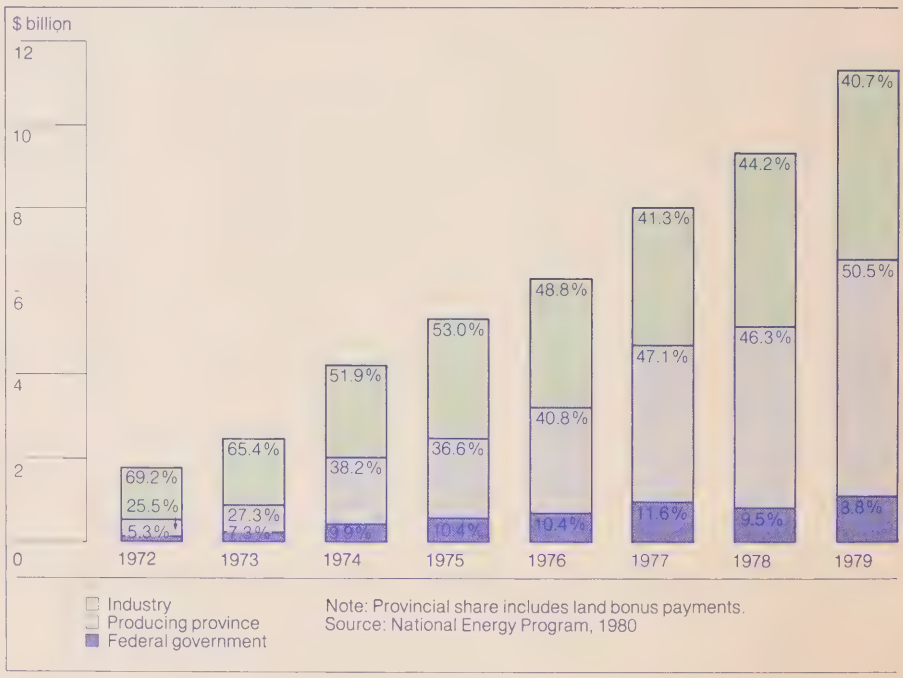
In 1973, following OPEC's decision to raise oil prices, the cost of a barrel of foreign crude oil landed at Montreal rose sharply from about three dollars to nearly twelve dollars in 1974 (Figure 34.) After that it continued to climb at a slower rate until 1979. Events in Iran led to sharp increases in the prices for spot purchases of crude oil well above official selling prices. The determination of many OPEC member nations to raise prices led to a doubling of official selling prices. Moderate members of OPEC, notably Saudi Arabia, have attempted to restrain escalating prices but with limited success. By fall 1980 the cost of a barrel of world crude oil landed at Montreal reached $38 (Cdn) a barrel.

FIGURE 32: Gasoline cost at Toronto pumps, November 1980



Note: Cents/litre, regular gasoline, representative price at full-service retail outlets

FIGURE 33: Historical sharing of oil and gas production income



Note: Provincial share includes land bonus payments.
Source: National Energy Program, 1980

United States oil prices

Since 1974 the United States has operated a regulatory program to control the price of crude oil produced domestically and to equalize the cost of crude oil among refiners by effectively averaging the costs of cheaper domestic oil and more expensive imported oil.

In June 1979 the United States began to increase domestic crude oil prices so that by 1 October 1981 they would equal world prices. As a sequel to decontrol of domestic crude oil prices, a windfall profits tax was introduced. Since that time, United States oil prices have escalated sharply (Figure 34). The U.S. refiners' cost of crude oil is moving closer to world oil price levels.

Canadian oil prices

From 1973 to 1980, Canadian oil prices rose as shown in Figure 34. Canada, with its own supplies of oil and other fuels, has been in a more favourable position than other industrialized nations. To protect Canadians from the severe economic consequences of the very sharp increases in world oil prices, the government of Canada established a single national oil price adjusted for transportation that was lower than the world price. After discussions with the provincial governments to determine the price level, the average Alberta wellhead price was raised to $6.50 a barrel in April 1974. In August 1980 the wellhead price was set by the federal government at $16.75 a barrel.

Figure 34 shows the cost of Canadian crude oil delivered to Toronto. In addition to the wellhead price, the cost includes the cost of transportation and the special levy introduced in 1978 to fund the payment of world prices to producers of synthetic crude oil from the oil sands. In December 1980 the price of Canadian crude oil in Toronto was about $20.30 a barrel.

The government of Canada announced a new Canadian oil and natural gas pricing policy in its budget presented on 28 October 1980 (Figure 35). This policy will establish prices for Canadian oil production based on Canadian conditions and not world prices. A new schedule of prices for domestic oil production and a new price system to blend the costs of different sources of oil, including synthetic crude oil and imported oil, into one weighted-average price to consumers was introduced.

FIGURE 34: World, United States, and Canadian crude oil prices

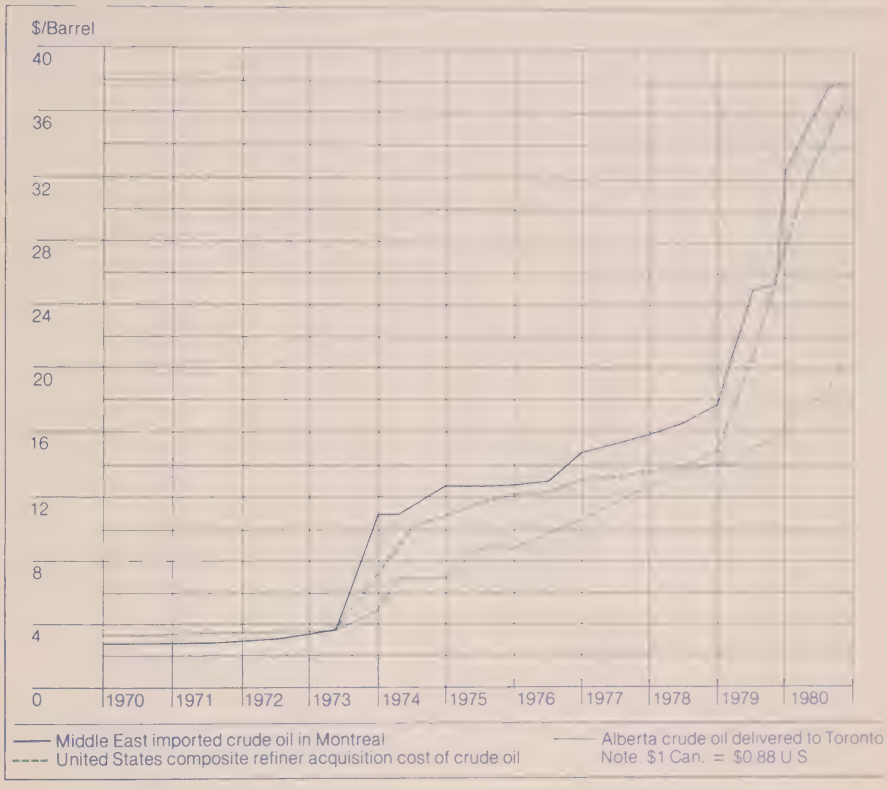


FIGURE 35: Crude oil and natural gas price schedule (1980-3)

Crude oil

Date	Wellhead price (conventional)	Petroleum compensation charge	Total
	($/barrel)		
31 Oct. 1980	16.75	1.75	19.50
1 Nov. 1980	16.75	2.55	20.30
1 Jan. 1981	17.75	5.05	23.80
1 July 1981	18.75	5.05	24.80
1 Jan. 1982	19.75	7.55	28.30
1 July 1982	20.75	7.55	29.30
1 Jan. 1983	21.75	10.05	32.80
1 July 1983	22.75	10.05	33.80

Note: Total crude oil price includes transportation cost of $1

Natural gas

Date	Eastern city gate price	Natural gas tax	Total
	($/thousand cubic feet)		
31 Oct. 1980	2.60	—	2.60
1 Nov. 1980	2.60	0.30	2.90
1 July 1981	2.60	0.45	3.05
1 Jan. 1982	2.60	0.60	3.20
1 Feb. 1982	2.75	0.60	3.35
1 Aug. 1982	2.90	0.60	3.50
1 Jan. 1983	2.90	0.75	3.65
1 Feb. 1983	3.05	0.75	3.80
1 Aug. 1983	3.20	0.75	3.95

Source: National Energy Program, 1980

A new charge, the Petroleum Compensation Charge, incorporating the earlier special levy, was also established, primarily to accomplish the blending of prices. The schedule of wellhead prices and the Petroleum Compensation Charge will lead to increases of $4.50 a barrel in the price of oil to consumers in each of the years 1981, 1982, and 1983.

An additional levy to be applied to oil and gas consumption to generate revenues for increasing Canadian ownership of the oil and gas industry was announced, but its level is yet to be established.

The government of Alberta has strongly criticized this new policy and has taken action to limit its oil production and new oil sands plant development. Further discussions between the governments of Canada and Alberta are expected.

Canadian natural gas prices

Since 1973 the price of natural gas at the Toronto City Gate has increased from $0.47 to $2.60 per thousand cubic feet. Since 1975 increases in the price of natural gas have been linked to increases in the wellhead price of crude oil.

In its October 1980 budget the government of Canada introduced a new natural gas tax initially set at 30 cents per thousand cubic feet on all sales of natural gas. A schedule of increases to the city gate price of natural gas, together with the natural gas tax, will lead to increases to the consumer of 45 cents per thousand cubic feet for the next three years.

Although crude oil and natural gas will both increase in price during the next few years, natural gas will do so more slowly than oil and thus become more competitive.

The government of Alberta has initiated a legal challenge to the natural gas tax.

Coal prices

The price of coal has risen sharply over the past few years. For example, the average cost to Ontario Hydro almost quadrupled from $0.45 per GJ in 1973 to $1.72 in 1979. The average cost of United States coal delivered to Ontario Hydro stations in 1979 was about $49/tonne. Most of these coal purchases are covered by long-term contracts lasting until the late 1980s containing renewable clauses and pricing arrangements that in many cases are based on cost. The delivered price for western Canadian coal in southern Ontario is some 40 to 50 per cent more than for United States coal because of the higher transportation costs.

Uranium prices

The current international market price for uranium is about $95 a kilogram. Ontario Hydro has secured its supplies of uranium for its operating and committed nuclear stations (including Darlington) under long-term contracts with two Canadian producers — Denison Mines Ltd and Preston Mines Ltd. Under the terms of these contracts the price charged to Ontario Hydro is related to the difference between a base (cost-determined) price and the world market price.

Canada and the world

Although energy prices are rising rapidly in Canada, it must be remembered that the country's vast wealth of energy resources has protected it from the worst effects of world energy price increases and supply reductions. We have seen that Canadians consume more energy per capita than citizens of other industrialized countries. We also pay less for energy than most other countries (Figure 36). The figure shows that the differences between the various world gasoline prices are accounted for in part by differences in the level of taxes being applied.

FIGURE 36: Retail gasoline and home heating oil prices for selected countries

Country	Gasoline		Home heating oil
	Cents/litre	Retail Sales Tax (% of retail price)	Cents/litre
Italy	97	64	44
Japan	93	41	50
France	90	55	45
United Kingdom	80	49	40
West Germany	76	49	42
United States	37	12	30
Canada	28	28	19
Ontario (Toronto)	28	28	18

Note: Prices as of October 1980
Source: Energy, Mines and Resources

Alternative energy supplies

Looming oil shortages and higher prices are a warning that immediate moves towards energy conservation are essential. As conventional energy supplies dwindle, increasing reliance must be placed on alternative forms of energy.

The term 'alternative energy' may denote several different things. In its simplest sense it refers simply to one fuel that may be substituted for another. In this sense electricity and natural gas are at present alternatives to oil for home heating in Ontario.

Secondly, it can refer to types of non-renewable energy that have previously not been widely used in an economy and usually require some lead time and much investment to produce. Today in Ontario lignite, peat, and oil shales are alternative energy supplies of this sort, just as uranium was twenty years ago.

Thirdly, alternative energy may refer to renewable and recoverable forms of energy. Renewable energy normally includes water-power, direct solar energy, wind energy, biomass energy (from renewable organic materials), tidal and wave energy, and geothermal energy (heat from inside the earth). Recoverable energy, often treated as a form of renewable energy, designates various kinds of energy from waste, such as municipal solid waste and residues of the forest products industry in Ontario.

Finally, alternative energy sometimes refers to experimental high-technology energy sources widely believed to hold much promise for the future, such as hydrogen and fusion.

In Ontario the substitution of alternative energy forms will probably occur in two broad phases. The depleting resources will at first tend to be replaced by other conventional energy sources in more abundant supply. Thus energy derived from natural gas, coal, and uranium will displace crude oil products in many uses. This kind of substitution, though not the final answer, will help Ontario cope with contracting oil supplies while the technology is being developed that will make available renewable and recoverable and high-technology energy resources.

An important criterion for future alternative energy supplies for Ontario is that as far as possible they should be produced from provincial resources. In 1979 indigenous provincial sources accounted for about 25 per cent of the province's primary energy consumption. The Ontario government has set a target of raising this proportion to 37.5 per cent by 1995.

Potential fossil fuel reserves in Ontario are being surveyed by the Ontario government. The Southwestern Ontario Oil and Gas Exploration Project has been established in conjunction with the Ontario Energy Corporation. The OEC is also examining the energy potential of Ontario's peat and oil shale deposits, the utilization of which may eventually become economically feasible.

The Onakawana lignite deposit in the James Bay lowlands is estimated to contain about 190 million mineable tonnes of low-grade lignite, equivalent to about 80 million tonnes of western Canadian bituminous coal. The prospects of developing this resource are now being examined by Ontario Hydro and Onakawana Development Ltd (a wholly owned subsidiary of Manalta Coal Ltd).

A study is examining the feasibility of establishing a 1000 MW mine-mouth electrical generating station. The lignite might also be used to make methanol, an alcohol fuel. The Ontario Energy Corporation has begun exploration for further lignite and other minerals in the area.

The prospects for hydrogen use in Ontario are being investigated. It may be stored and moved by pipeline and could be used in internal combustion engines or in fuel cells to generate electricity. It can be manufactured by passing an electric current through water in a process known as electrolysis. Thus, like electricity itself, it is a secondary, not a primary, energy source. However, because Ontario has abundant electrical generating capacity, hydrogen may become a useful energy form in the province.

Transmission of energy in the form of hydrogen by pipeline over long distances may be more efficient than transmitting high-voltage electricity. Amongst applications for hydrogen are its possible use in conjunction with the production of petroleum from deposits of oil sand, heavy oil, and oil shale, with the upgrading of oil refinery residuals, and with the production of synthetic liquid fuels from biomass. Moreover, vehicles, even aircraft, powered by hydrogen may become feasible.

The Ontario government has set up a task force on hydrogen to assess the present state of the technology and economics of production and utilization of hydrogen and to examine the possible role of hydrogen, particularly from non-hydrocarbon sources, in the province.

Controlled nuclear fusion is a primary energy source now subject to much experimentation in the United States, the USSR, Japan, and the major European countries.

Although the federal government has prime responsibility for the advancement of fusion technology at the present stage of its development, the Ontario government has for the past several years been supporting fusion materials and engineering studies at the University of Toronto's Institute for Aerospace Studies and at McMaster University. Recently, Ontario announced a grant of $250 000 over five years in support of the program at the University of Toronto.

With its heavy water production plants as a source of deuterium and its CANDU reactors as a source of tritium, Ontario is in an excellent position to be a world supplier of these hydrogen isotopes, which are the basic fuels for fusion reactors.

Renewable and recoverable energy

Renewable and recoverable energy sources accounted for 14 per cent of the province's energy supply in 1979. Most of that was in the form of water-power used to generate electricity.

Of the many other types of renewable energy, some, such as geothermal and tidal, are not available in Ontario and others, such as photovoltaic conversion of sunlight to electricity, will become feasible only as a result of major research programs, some of which are already being carried out in the United States. Ontario's renewable energy program therefore concentrates on the three most promising areas: energy from waste and biomass, solar space and hot water heating, and remote power systems (wind and small-scale hydraulic systems for the generation of electricity in remote areas).

These three sources of renewable energy could account for the annual equivalent of 7.8 million cubic metres of crude oil (CMOE), or more than 5 per cent of the province's energy requirements, by the year 1995 (Figure 37). However, even to achieve that level in so short a time presents a major challenge and will involve the investment of about $16 billion over the next fifteen years by individuals, industries, Ontario Hydro, municipalities, the federal government, and the government of Ontario.

A five-year, $58 million Canada/Ontario Bilateral Agreement has been signed to fund the development and demonstration of conservation and renewable energy technologies.

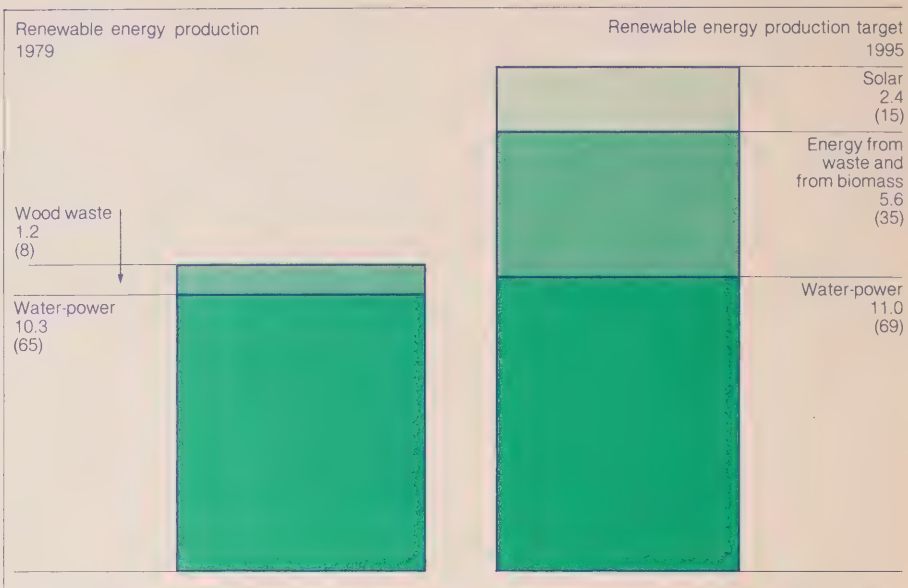
Energy from waste and biomass

By 1995, energy from waste and from biomass could supply an additional 4.2 million CMOE above the 1979 level of 1.2 million CMOE. The most immediate opportunity using techniques already proven is in municipal solid waste installations (1.1 million CMOE potential by 1995). Some further technical developments are required to utilize further the mill and bush residues of the forest products industry (1.5 million CMOE), agricultural crops and waste (0.7 million CMOE), and biomass energy plantations (0.9 million CMOE). We shall briefly examine each of these in turn.

Municipal solid waste (MSW)

Every year in Ontario some six million tonnes of municipal solid waste are created. Roughly half of it is paper, and much of it is highly combustible. Each tonne on average contains slightly more

FIGURE 37: The potential of renewable energy in Ontario by 1995



Note: Amounts are in annual equivalents in millions of cubic metres of crude oil (millions of barrels of crude oil in parentheses).

FIGURE 38: Some municipal solid waste projects under evaluation in Ontario

Project	Waste quantity (tonnes/year)	Energy product: Type	Energy product: Oil equivalent (m^3/yr)	Estimated cost of facility ($ million 1980)
Hamilton — Tricil/SWARU	110 000	Steam	19 200	8.0
London — Victoria Hospital	70 000	Steam	12 200	20.0
	127 000	Steam	22 200	37.0
Niagara — Ontario Paper	211 000	Steam/ Electricity	36 900	75.0
	586 000	Steam/ Electricity	102 500	95.0
North Bay — Nordfibre	60 000	Steam	10 500	9.0
Ottawa-Carleton — District Heating Project	275 000	Steam/ Electricity	48 000	75.0
Owen Sound — Hospital Project	14 000	Steam	2 500	3.0
Peel Region	296 000	Steam	51 800	79.0
St Catharines — General Motors Project	56 000	Steam	9 900	9.5
Sudbury — Inco Project	96 000	Fuel/Compost	16 800	15.0
Toronto — Commissioners Street Project	187 000	Steam	32 700	8.0
— District Heating Incinerator	380 000	Steam	66 400	80.0
— R. L. Hearn Generating Station	490 000	Steam/ Electricity	85 700	110.0
Demonstration projects				
Toronto — Watts from Waste	250 000	Electricity	43 700	55.0
Woodstock — Cement Plant	80 000	Fuel	14 000	0.3

Note: Because some of these projects might compete for the same refuse, not all of them may go ahead. The differences in cost reflect not only economies of scale but also differences between extension of existing plants and construction of complete systems.

recoverable energy than a barrel of oil. At present almost all of it is buried as landfill or incinerated with no heat recovery, in spite of the proximity of large energy consumers and the problems being encountered in urban waste disposal. Since waste collection and transportation systems are already functioning and the conversion technology has been widely proven in European and American cities, it is clear that in municipal waste Ontario has a valuable untapped energy asset.

Figure 38 gives details on fourteen MSW projects now under evaluation in Ontario.

Mill and bush residues

Many forest industry plants already burn some of their mill residues to produce steam and electricity. But more than 1.5 million oven-dried tonnes of mill waste continue to be discarded, mainly sawdust, bark, and chips from sawmills, amounting to nearly 0.5 million CMOE. Figure 39 shows a number of mill residue recovery plants now operating in Ontario.

A much greater quantity of wood waste created every year is less accessible, however; bush residues are the branches, slash, and other cuttings left in the forest from trees removed by loggers, as well as trees killed by fire, insects, and disease and wood produced by rehabilitating cull stands or thinnings. Representing 30 to 60 per cent of the wood cut down, bush residues would produce a sustainable supply of 6 to 10 million oven-dried tonnes a year. Exploitation of this resource depends on the development of economical harvesting techniques. Although the environmental effects of large-scale biomass removals on a particular site have yet to be determined, the utilization of dead timber and the rehabilitation of cull stands would in general benefit the established forest products industry.

Since much of the mill and bush waste will not have been dried, its weight would make the transportation of it more than a few miles quite expensive. A method of upgrading the fuel value and lowering the weight of the waste is being developed by Shell Canada, whose wood waste pelletizing plant at Hearst will have a fuel pellet production capacity of 59 000 CMOE.

Another method of utilizing wood residues is to produce fuel gas at the sawmill. A Canadian-built, fluidized-bed wood gasifier is being demonstrated in Hearst at a plywood mill, a project supported by the federal and Ontario governments.

Agricultural crops and waste

The Energy Agriculture committee established by the Ontario government is reviewing the question of energy security for Ontario's agricultural industry and considering how the production of

FIGURE 39: Some mill residue energy recovery plants

● Forest (mill) residues (including cogeneration)

fuel from crops and agricultural waste can contribute to energy self-sufficiency on the farm.

Animal manure, grain residues, and straw are rarely used at present in Ontario to produce energy. Methane gas can be produced from manure by a process that also improves the manure as fertilizer. Several of these 'biogas' digester plants are already in commercial operation in the United States, but in the Canadian climate farm-scale operation requires further technological development. The Ontario government is sponsoring a program at the University of Guelph to develop an economical, small-scale, methane converter for Ontario farmers, and a demonstration plant has been constructed at the University's research centre at Arkell, Ontario.

Grain residues and straw may eventually be used to help heat farm buildings.

Crops such as corn, sugar beets, potatoes, Jerusalem artichokes, and barley from poor or underutilized farmland could be directed to the production of ethanol, which can be used straight or blended with gasoline as a vehicle fuel. The Ontario government is assisting in the construction of several demonstration farm-scale ethanol stills across the province. It is estimated that 2 million tonnes a year of corn stalks and leaves now ploughed in, if not needed as fertilizer and humus, could be used as a feedstock for ethanol production if new processes to convert and ferment cellulose become viable.

Biomass energy plantations

Tree plantations for energy purposes may become common in Ontario. Experiments now being undertaken by the Ontario government near Cornwall show the sustainable biomass production rate from hybrid poplar to be about thirteen times the growth rate for other trees in the area. Plantations could be established on farmland that is too wet or stony for conventional agriculture. The trees could be grown on a very short rotation cycle (two to twelve years) and would normally not need fertilizer once the root systems become well established.

Under a current program with Domtar Ltd, 5000 acres of poplar plantations will be established in the Cornwall area by 1985 as a source of wood fibre for its pulp operations. Similar plantations could be developed for energy supply purposes.

Synthetic liquid fuels

Owing to the vulnerability of the transportation sector to oil shortages, there is an urgent need to develop alternative transportation fuels. Propane and compressed natural gas are already being used in commercial fleets. In the near future it may become economically attractive to produce alternatives to gasoline.

The Ontario government's recently announced Alternative Transportation Fuels Program will hasten the development and commercialization of a wide range of such fuels, including those from biomass.

The alcohol fuels, ethanol and methanol, can be used in low-level (3 to 10 per cent) blends with gasoline in standard engines without modification or they can be used straight in vehicles with special engines. Methanol can

FIGURE 40: Active solar demonstration projects in Ontario

Name	Location	Description
Provident House (with federal government)	King City	Space heating system with annual storage for single family home
Package domestic hot water systems	2 in East Toronto 2 in West Toronto	Water heating in a single family residence
Solar furnace	East Toronto	Space heating in a single family residence using a packaged system
Aylmer Senior Citizens' Home	Aylmer	Space heating with annual storage for a multiple family home
Confederation College	Thunder Bay	Water heating
Centralia College	Centralia	Water heating
West Humber Collegiate	Etobicoke	Water heating
Applewood Public School	St Catharines	Space heating in conjunction with a heat pump
Ontario Correctional Institute	Brampton	Water heating
Oakville Trafalgar Hospital	Oakville	Water heating with no storage
Richvale Community Centre	Richmond Hill	Heating of a swimming pool
Newmarket Court House	Newmarket	Space and water heating of an office building
Solar grain drying	University of Guelph	Grain drying
Sudbury Civic Centre	Sudbury	Water heating for an office building
Provincial Park Comfort Stations (13)	Northern and Southern Ontario	Water heating for comfort stations in two different regions
Mohawk Laundry	Hamilton	Water heating
Cambrian College	Sudbury	Water heating
Low-rise apartment building	Toronto	Water heating

Note: All these solar energy systems are supplemented by another energy form such as electricity or natural gas.

also be used to manufacture synthetic gasoline, which could be distributed and used like ordinary gasoline.

A blend of ethanol and gasoline called gasohol is already available in parts of the United States and Canada. Ethanol, however, can as yet be manufactured commercially only from agricultural crops or primary food processing waste; methanol, which can now be made from natural gas or coal and may soon be made from wood, needs further development of a distribution system. But the technology is advancing rapidly.

Solar energy

There are two basic types of solar heating systems: passive solar systems (where the building itself collects and stores heat) and active solar systems (where a separate heat collection, storage, and distribution system is attached to a building).

Ontario's solar energy program aims to meet 2 per cent of Ontario's energy requirements by 1995 (equivalent to 2.4 million CMOE, enough to heat 700 000 homes) by helping the private sector make solar technology commercially available.

The recently announced Solar Energy Strategy for Ontario will provide $50 million over five years to help the private sector develop cost-effective, reliable solar equipment. Priority will be given to residential passive solar heating, residential water heating, commercial and industrial hot water and process heat, swimming pool heating, and agricultural space and process heating.

Figure 40 lists the active solar demonstration projects now under way in Ontario. Provident House was the first government-sponsored solar energy demonstration project. The largest solar energy project completed by the Ontario government to date is the installation of a solar system at the Oakville Trafalgar Hospital to preheat the 34 million litres of hot water required annually for hospital laundry and other domestic applications. Figure 41 shows a type of residential solar hot water heating installation now available commercially in Ontario.

An Ontario government project for the design of passive solar heated homes was conducted jointly with the Housing and Urban Development Association of Canada. Twenty-one selected designs are now being constructed, and their performance and costs will be comprehensively analysed.

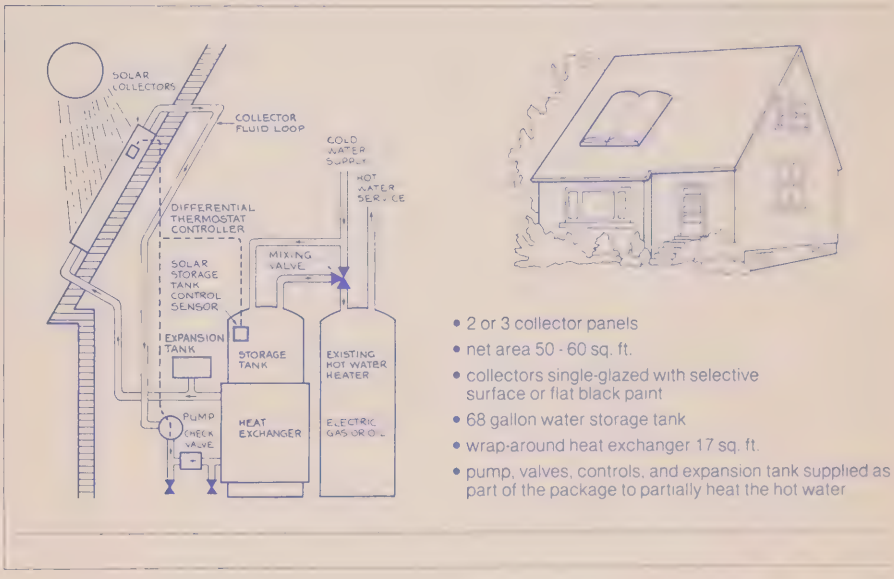
A number of applications of solar energy to agriculture are under way. Greenhouse options are being examined at a horticultural station in Vineland, including an internal environmental control system. The results at Vineland are being monitored to ascertain that crop yield is not jeopardized by energy conservation.

Solar grain drying is being studied at the University of Guelph, and applications of active solar heating in various farm dwellings are also being reviewed.

Reliable monitoring and assessment techniques are vital for equipment manufacturers and building designers, owners, and managers. A new monitoring approach has been developed and will be applied at the Ontario Correctional Institute in Brampton.

Further studies are reviewing the institutional factors and regulations that affect the choice of solar energy systems. These include building codes, certification standards for equipment safety and reliability, and consumer protection, as well as the question of legal access to sunlight.

FIGURE 41: Packaged solar hot water heating systems for single-family homes, Toronto



- 2 or 3 collector panels
- net area 50 - 60 sq. ft.
- collectors single-glazed with selective surface or flat black paint
- 68 gallon water storage tank
- wrap-around heat exchanger 17 sq. ft.
- pump, valves, controls, and expansion tank supplied as part of the package to partially heat the hot water

Remote power systems: wind, water, and wood

There are still some isolated communities in northern Ontario, as well as cottages and telecommunications stations, not connected to an electrical power system. In remote locations the traditional power supply has been the diesel-powered generator. But the cost of diesel fuel has been rising steadily, and where fuel must be transported by air it can cost up to five times as much as it does in southern Ontario.

A number of renewable energy systems have therefore been examined as alternatives to transmission line extensions or as supplements to diesel installations. These include combined wind-diesel power systems, small-scale hydroelectric units, and wood gasifiers.

Photovoltaic cells may be useful in remote applications with low power needs, such as radio beacons and air quality monitors.

Over most of Ontario the average winds are light (Figure 42). With wind generation alone, costly electrical storage capacity would be needed. An alternative being investigated is a hybrid system in which the diesel generator provides the base power while the wind turbine helps out when winds are favourable. Wind power seems a practical supplement to diesel power only where the mean annual wind speed is at least 20 km/h. Such wind conditions occur in coastal areas of the Great Lakes and James Bay.

The Ontario government will construct and operate a 50 kilowatt wind/diesel hybrid system in the Sudbury area. This co-operative demonstration project will be operational in early 1981 and will run for two years.

Ontario Hydro is also testing the integration and control of small wind generators connected to the grid.

In northern Ontario there is still some undeveloped hydraulic capacity at several existing sites. A number of developments in small-scale hydraulic turbine units have opened up a new range of applications, particularly for community power in remote communities. A small-scale hydraulic turbine is now being demonstrated at Wasdell Falls, and four other locations have been studied by Ontario Hydro. A field demonstration project is scheduled for operation late in 1980 at Sultan, north of Sudbury.

The Ministry of Energy is in process of selecting a site for a small-scale wood gasification pilot plant connected to an engine/generator set.

Ontario can make a significant contribution to the national goal of crude oil self-sufficiency for Canada by 1990. Oil substitution and energy conservation targets have been set by the Ontario government for each sector of the economy, and they were revised on 10 October 1980 (Figure 43).

If those targets are reached, the growth in secondary energy consumption, which from 1973 to 1978 averaged 2.3 per cent annually, would from 1980 to 1995 average only 1 per cent annually. Furthermore, in 1995 Ontario's demand for crude oil would be 3.7 million cubic metres less than it is today.

As part of the National Energy Program the federal government announced the Canadian Oil Substitution Program with the objective of reducing oil consumption to 10 per cent of total energy requirements in the residential, commercial, and industrial sectors.

This ten-year program, effective from 28 October 1980, will provide to householders and businesses, institutions and non-profit organizations, incentives to convert from oil to other fuels for their heating systems. The program will also provide grants for the expansion and upgrading of delivery systems for natural gas, electricity, and other energy forms such as wood, solar, and wind. Discussions on the implementation of this program are proceeding between the federal and Ontario governments.

This section reviews some of the Ontario energy conservation programs and their impact.

Transportation

About half of Ontario's crude oil consumption occurs in transportation, which is almost entirely dependent on oil products and therefore particularly vulnerable to crude oil shortages. The specific targets set for the transportation sector are to achieve by 1995 an improvement in energy efficiency over 1980 levels of 50 per cent in passenger transportation and 20 per cent in freight transportation.

To help realize those targets the Ontario government has established the Transportation Energy Management Program (TEMP). The broad program combines energy conservation initiatives in all areas of transportation.

Trucksave, a joint industry-government advisory group, has been formed to guide energy conservation research

FIGURE 42: Wind speeds in Ontario

Note: Isovents of annual mean wind speed in kilometres per hour at 30 metres altitude

and demonstration projects in freight transportation. A driver training package has been produced to encourage truck drivers to adopt fuel-efficient practices. Savings of up to 15 per cent in expenditures for fuel and vehicle maintenance have been logged.

The Driver Efficiency program, directed similarly to drivers of automobile fleets such as taxis, has also begun.

About 30 per cent of gasoline is consumed for commuting. If car occupancy on commuter trips had increased by only 1 per cent through more commuters leaving their cars at home and using automobile pools, the gasoline saving in Ontario would have been 34 million litres in 1980.

To promote such savings the Ontario government has launched a rideshare program. Carpooling and vanpooling demonstration projects are under way across the province and show significant financial savings for commuters as well as providing less stressful, door-to-door service. Area-wide commuter matching services are being developed. Employer-sponsored pools have been found particularly effective, and the commercial viability of leasing vans to commuter groups on a fee-for-service basis is being tested in Toronto and Ottawa by the Ontario Energy Corporation.

The commercial feasibility of computerized transit information systems for public transit riders is being tested by the Ontario Energy Corporation and Teleride Corporation in a demonstration project in Mississauga.

In the operations of its own fleet of vehicles the Ontario government plans to reduce fuel consumption by 10 per cent by 1983 and is introducing energy conservation criteria into equipment selection, fleet utilization, and driving and maintenance practices.

A series of programs has been developed to help municipalities formulate transportation plans. The municipal programs support studies of vehicle traffic flow, parking control, transit options, and all aspects of urban transportation energy management.

The avoidance of unnecessary travel is of course an important part of energy conservation, especially in a large country. The Ontario government is now demonstrating different kinds of teleconferences in which special equipment allows easy communication between groups of participants in widely separated regional offices

FIGURE 43: Energy security targets for Ontario

Sector	Energy conservation targets	Oil substitution targets
Transportation	• 50 per cent improvement in passenger miles per unit fuel consumption and for freight 20% per cent in unit fuel consumption per ton mile by 1995 over 1980 • for Ontario government fleet, 10 per cent improvement in energy efficiency by 1983	• reduce oil share to 90 per cent by 1995
Residential	• 30 per cent improvement in average household energy efficiency by 1995 over 1980	• reduce oil share to 10 per cent by 1990
Commercial	• 20 per cent improvement in commercial building energy efficiency by 1995 over 1980 • for Ontario government buildings, 26 per cent reduction in energy consumed by 1985 over 1976	• reduce oil share to 10 per cent by 1990
Industrial	• 25 per cent reduction in energy per unit output by 1985 over 1975	• reduce oil share to 10 per cent by 1990

Indigenous energy production targets
- to produce 37.5 per cent of Ontario's primary energy in 1995 from indigenous provincial sources
- to produce at least 5 per cent of Ontario's primary energy requirements from renewable and recoverable energy sources by 1995. This target excludes the contribution of hydroelectric power.

FIGURE 44: Fuel economy in new car fleets (litres/100 km)

Corporate average fuel economy	Model year		
	1978	1979	1980
U.S. mandate	13.1	12.4	11.8
American Motors	12.6	11.8	10.9
Chrysler	12.8	11.5	11.0
Ford	12.8	12.3	10.7
General Motors	12.4	12.3	10.8
Volkswagen	8.6	8.3	7.6

Note: Based on number of each make and model sold each year in the United States combined with fuel economy values for each car.
Source: Dupont Petroleum Chemicals, 1980 Canadian Technical Conference

A great deal of transportation energy conservation remains a question of automobile technology. In Ontario ways are being tested to improve the fuel economy of existing vehicles, including fuel-efficient lubricants, radial tires, and cold-weather aids such as block heaters. As to future vehicles, each year the new car fleet in North America consumes less gasoline because of the fuel economy standards legislated in the United States (Figure 44).

As a development incentive for new automobile fuel technology, the Ontario government removed the sales tax from licensed vehicles powered exclusively by electricity or the combustion of hydrogen, propane, natural gas, alcohol, or manufactured gas. These fuels were also exempted from Ontario gasoline retail taxes.

The Ontario government has also recently announced a comprehensive, five-year, $75 million program aimed at developing and demonstrating the production and utilization of alternative transportation fuels to the point of commercialization.

An important Ontario initiative to reduce oil consumption is the Drive Propane demonstration project. One hundred private and one hundred public vehicles across the province, mostly vans, have been equipped to burn propane, and their performance is being

monitored for a year. The results of this project will be of particular interest to truck and automotive fleets of ten vehicles or more that have central fuelling and maintenance facilities.

Residential

In this sector the Ontario government's target is to improve the energy efficiency of the average Ontario household by 30 per cent from 1980 to 1995.

A leading Ontario residential conservation initiative is Project HeatSave, combining thermographic surveys with individual energy audits and consultations. Such thermography information clinics were thoroughly tested in 1979 in six Ontario centres — Lindsay (the first in Canada), Stratford, Peterborough, Kingston, St Catharines, and Cornwall.

Infrared scanners mounted in an aircraft detect heat lost through and around roofs of houses, and the resulting thermograms — heat pictures which show heat escaping from buildings—are discussed with individuals who attend the clinics to identify heat loss problems and possible solutions. Insulation literature and audit programs provide additional information and guidance on how the problems might be corrected.

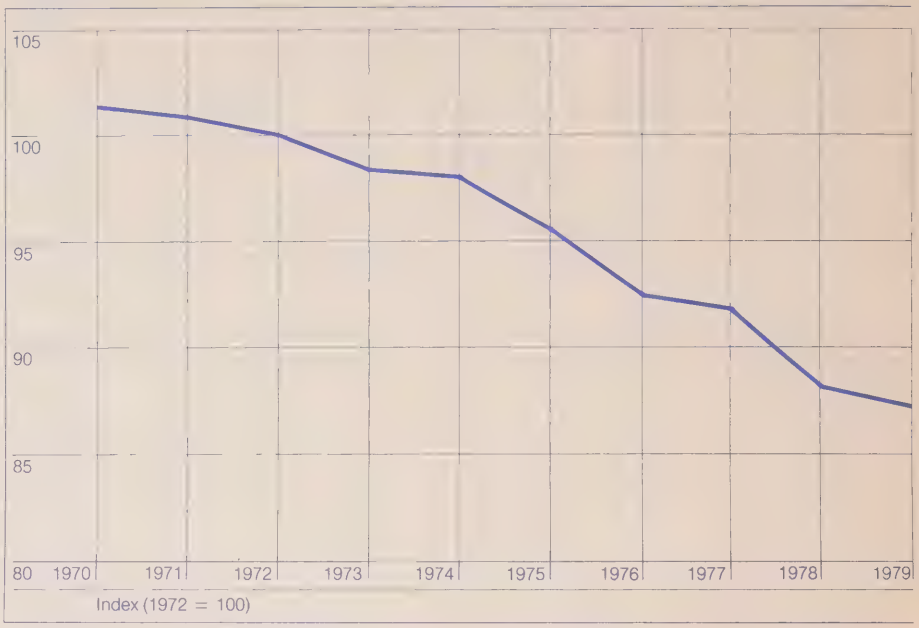
Out of those tests grew a five-year program to deliver the clinics to sixty large Ontario communities by 1985. Full-scale HeatSave projects began in fall 1980 in Sault Ste Marie, Sudbury, Pembroke, and Belleville.

In 1977 the federal government introduced the Canadian Home Insulation Program (CHIP). By November 1980, 450 000 Ontario residents had received $155 million from the program to upgrade the insulation in their homes and reduce heat loss.

The Ontario government through its Housing Energy Management Program (HEMP) is supporting research and development on the upgrading of existing houses and on equipment and standards for future housing construction. Types of insulation, ways to reduce the thermal conductivity of masonry walls, changes to the heating system needed when converting from oil, such as altered chimneys, and methods of central heat control in high rises are areas in which progress is being made.

An investigation by the Canadian Gas Research Institute funded in part by the Ontario government has led to the development of high-efficiency residential gas furnaces reaching about 92 per cent seasonal efficiency. They are now entering prototype production in Canada and should begin appearing on the market in a year or two.

FIGURE 45: Average use of natural gas per residential space heating customer in Ontario



Teacher training programs and curricula in energy conservation are under way for courses in environmental studies, while audiovisual materials, booklets, and models for use in the classroom are being prepared in the Ontario government's energy education program.

Residential energy conservation is already getting results. The Canadian Gas Association has found that average space heating use per customer from 1972 to 1979, after adjustment for temperature variations, decreased by 12.5 per cent (Figure 45).

As noted in the earlier discussion of natural gas, more and more homeowners are converting their heating systems away from oil to natural gas. The Canadian Oil Substitution Program could strengthen this trend. Moreover, increasing numbers of homeowners are expected to switch to electricity and other fuels such as propane and wood for all or most of their home heating needs.

Commercial

The target in this sector is to improve the energy efficiency of commercial buildings in Ontario by 20 per cent from 1980 to 1995. In Ontario government-owned buildings the goal is a 26 per cent reduction in total energy consumed from 1976 to 1985.

The chief provincial energy conservation programs in this sector are the Energy Management Program for buildings owned and funded by the Ontario government, the Municipal Energy Conservation Program for the 837 autonomous municipalities in the province, and the Downtown Program for the private commercial sector.

The Energy Management Program began in 1976 with the target of reducing energy use in all government-owned buildings by 15 per cent over five years, not only as a conservation measure in itself but also to set a solid example of what a commitment to energy conservation can achieve. Within the first two years the goal was surpassed. It was extended another five years with the goal of a further 7.5 per cent reduction in consumption.

Oil now supplies 30 per cent of the space heating requirements of buildings owned by the Ontario government, and 338 of these buildings have been identified as appropriate for conversion to other energy forms. A $2.5 million program has been established for this purpose.

Energy conservation measures are also under way in buildings not owned but funded by government, such as schools, universities, and hospitals. Though outside the Energy Management Program, many of these institutions have shown comparable savings.

The following are a few outstanding examples of the energy savings being achieved in buildings owned or funded by the Ontario government. A court house in Barrie shows how effectively energy can be saved through careful design. Constructed in 1976, this building incorporates heavy construction walls, small, double-glazed windows, a variable air volume system, a heat recovery system, and a heat pump system. It cost no more to construct than a conventional building but uses less than one-quarter of the energy that used to be the norm for government buildings.

Sir Robert Borden School, an all-electric school in Ottawa, has cut its energy consumption by 53 per cent since 1973. This outstanding saving was achieved by retrofitting mechanical systems, training operators, preventive maintenance, and turning systems off when not required by building occupants.

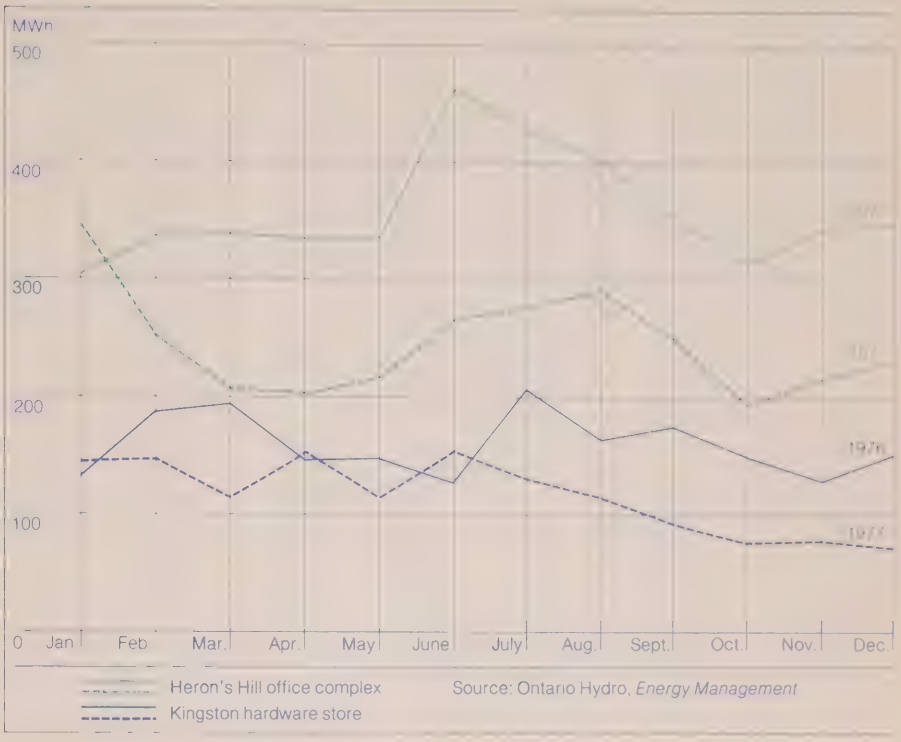
The Vanier Institute for Women reduced its energy consumption by 31 per cent over two years. Major energy conservation measures included reduction of air volumes, the addition of storm windows, and closing down the steam boiler each weekend throughout the summer.

London University Hospital achieved a 50 per cent reduction in energy consumption between 1973-5 and 1979. The hospital saved $200 000 in 1979 alone through reduction in steam consumption by cutting off 450 of about 700 steam reheat coils. Other measures included peak load monitoring, installation of a centralized computer system, and installation of a glycol runaround system.

The experience gained by the Ontario government's Energy Management Program has helped form the basis of two other conservation programs. The Municipal Energy Conservation Program, established in 1979, helps municipalities become efficient users of energy and leaders in conservation by offering technical assistance, seminars and workshops, and printed and audiovisual materials. Already 150 municipalities encompassing more than 80 per cent of the province's population have adopted the program, appointing energy co-ordinators and committees.

The Ontario government has recently announced a $12 million energy conservation and off-oil conversion program for municipal buildings and public institutions. Cost-sharing grants will be made for two kinds of projects: conversions from oil-burning equipment to natural gas, electricity, or other energy sources such as wood and local waste fuels; refitting existing oil-heated buildings with energy-saving materials and equipment such as insulation, heat recovery systems, timers, and thermostat controls.

FIGURE 46: Commercial sector energy conservation



Source: Ontario Hydro, *Energy Management*

The Toronto Downtown Program, directed at the private sector and launched in April 1978, is aimed at persuading owners and managers of downtown buildings to conserve energy. Since the program began, thirty owners and managers of downtown Toronto buildings have appointed energy co-ordinators, and seventeen of the city's largest building owners and tenants have reported savings of almost 22 per cent. A similar downtown program is being set up in Ottawa.

Marked savings in electricity consumption have been achieved through fairly simple conservation measures. By improved control of the heating, ventilating, and air conditioning system, the application of solar film to some windows, and regular practice of a lights-out policy, a commercial office building complex in North York saved more than 30 per cent in annual electricity consumption (Figure 46). The same diagram shows how a hardware store in Kingston saved 27 per cent in annual electricity consumption merely by cutting out 50 per cent of its lighting load; lighting levels dropped by about one-third and sales were not affected.

Industrial

The target in this sector is to achieve a 25 per cent reduction in the energy required per unit output by 1985 compared with the 1975 level.

In 1975, to encourage greater awareness among industrial decision-makers of energy costs in production processes and the adoption of energy conservation techiques, Ontario, in co-operation with the federal government, introduced the first Energy Bus program in Canada. Computer-equipped buses help businessmen make on-the-spot analyses of energy consumption and identify potential savings. So far about 1150 companies have been visited in Ontario, and annual cost savings of $48 million have been identified.

The Ontario government recently announced the $10 million Ontario Industrial Energy Conservation and Oil Substitution Incentive Program for which any Ontario-based company is eligible. This program will give high priority to converting existing oil-burning equipment to more abundant fuels, such as natural gas. New installations and improvements in the energy efficiency of existing plant and equipment can be partially financed through this program.

The conservation investments being encouraged include insulation of pipes, tanks, and roofs, heat exchangers to improve boiler efficiency, fans to move hot air from ceilings to working levels, and instrumentation to regulate and measure energy utilization. A company can receive up to $50 000 under the program.

These initiatives are complementary to those of the fourteen task forces on energy conservation that have been established by the federal government and industry across Canada. Figure 47 shows that, on average, industry has exceeded its 1980 goals at least one year early.

Another energy conservation opportunity being investigated is cogeneration of heat and power by large industries. A plant producing and using large quantities of steam may wish to use excess amounts to generate electricity either for its own use or for sale. Industrial plants cogenerating electricity for their own use include Great Lakes Paper in Thunder Bay, American Can in Marathon, and Dow Chemical in Sarnia. The Abitibi Paper Company, as well as cogenerating electricity for its own use, also supplies part of the power consumed by the town of Smooth Rock Falls. Other pulp and paper companies supply electricity to the surrounding towns of Marathon and Terrace Bay.

Ontario Hydro has declared its support for industrial cogeneration and is reviewing its policies for the purchase of power from and sale of power to industrial cogenerators, and recent changes in charges and connections have made such arrangements easier for small producers. An estimated 700 MW of electrical capacity could be achieved through industrial cogeneration in the 1980s, about equivalent to a large thermal generating unit.

Another type of cogeneration is represented by the recovery of by-product heat from thermal generating stations, where only about one-third of the heat produced in the boilers is converted to electricity. Much of the remaining heat is transferred to water circulated as coolant and ultimately dissipated in adjacent lakes and rivers. Usable hot water could be made available in large quantities year-round and could be used for agricultural, residential, and industrial purposes in the vicinity of the generating station.

The Bruce AgriPark, a project in which the Ontario Energy Corporation participates, plans to use reject warm water from the Bruce nuclear power complex for greenhouse heating and for aquaculture, whereby the growth rates of some fish can be accelerated by two or three times. A demonstration is operating at Kincardine. Eventual plans call for 150 acres of greenhouses and a number of fish-farms. The Corporation and its partners are now proceeding with the development of an industrial park adjacent to the Bruce complex.

A smaller demonstration greenhouse is being operated by Ontario Hydro at its Pickering Nuclear Station.

The use of waste heat from pipeline compressor stations and from exhaust gas in mining operations to heat greenhouses is being explored in other power-sharing projects by the Ontario Energy Corporation.

Ontario Hydro is training more than two hundred energy conservation surveyors from Hydro and municipal utilities to audit the energy consumption of some 12 000 small- to medium-sized industrial plants in the province. Hydro also conducts seminars on industrial energy conservation in various Ontario centres.

Urban development

The Ontario government undertakes a number of projects to introduce energy conservation criteria into land use planning. Medium-density residential accommodation is encouraged because of its energy advantages for heating and transportation.

Compact, mixed-use development in urban areas, downtown centres in preference to suburban ones, building inside rather than around the edges of cities where possible, and district heating opportunities are some of the urban forms advocated. Energy-sensitive landscaping and solar access are also important.

Planners are encouraged to promote transportation by foot and bicycle and by public transit in preference to the private automobile. Urban waste management systems with energy recovery potential are also a priority.

Recent studies include *Energy Efficiency in Municipalities: the law*, a review of legal tools available to municipalities; *New Directions in Municipal Energy Conservation: the California experience*, an examination of successful experiments in California and their applicability to Ontario; *Mississauga City Centre Energy Study*, the energy-conscious design and planning of a large, mixed-use, urban centre; *Woodstock Zoning Bylaw Review Study*, in which an Ontario municipality studied the introduction of energy conservation measures into its bylaws; and *Subdivisions and Sun*, which helps architects, planners, and developers become more aware of ways to use solar energy in planning residential areas.

FIGURE 47: Industrial sector energy conservation

	Energy efficiency improvement (%)	
Task force	1980 goal	1979 actual
Chemicals	17.0	22.0
Electrical & electronics	15.0*	21.8
Ferrous metals	3.3	2.4
Food & beverage	15.0	10.7
Industrial minerals	10.0	9.6
Machinery	15.0	18.7
Mining & metallurgy	5.8	3.6
Petroleum refining	18.0	16.5
Plastics	new	15.7
Pulp & paper	12.0	13.7
Textile	11.0	21.1
Transportation	15.0*	5.9
General manufacturing	new	new
Wood products	new	new
Average	12.0	13.0

*based on prior methodology which has been revised
Note: Percentage efficiency gains are calculated on the basis of the energy required to manufacture one unit of production in the current year compared to that required in a base year, usually 1972.

The first part of this report outlined Ontario's present energy picture. This part looks to the future.

In planning for the future it is possible to take either of two approaches. One approach is to select a target level of energy consumption and then force events in order to achieve that level, such as by prescribing how much energy each individual would be allowed to use. Another method, the one used in this analysis, is to forecast the growth in energy consumption, using current trends and anticipating events to identify potential future problems. Then, by taking appropriate action, it may be possible to avoid those problems.

The simplest kind of forecast merely projects the province's current energy consumption patterns forward to, say, the year 2000 to see where they are leading. However, significant changes could obviously occur in the structure of energy supply and consumer demand over the next twenty years. To take account of such possibilities, forecasters construct a model that allows certain basic assumptions about the future to be altered. They are then able to present a range of possible future consumption patterns.

The Ministry has developed a forecasting model that enables us to project energy demand over the next twenty to twenty-five years using a variety of different assumptions. The model is useful for quantifying the effect on future energy use of technological changes and socio-economic developments.

Obviously no one can accurately predict future events, but the value in trying to anticipate energy supply and demand comes from the heightened awareness and greater sensitivity to the various factors interacting in and shaping the future. As a result of this greater awareness one is able to take action earlier than might otherwise have been possible.

The major assumptions made by the following forecast, prepared early in 1980, are as follows:

- there will be no major technological breakthroughs affecting energy use;
- only policy measures that are now implemented, or widely accepted as sure to be implemented, are considered;
- no major social or political upheaval will radically change the structure and pattern of energy use;
- the marketplace will continue to determine resource allocations;
- consumers will actively pursue energy conservation opportunities;
- alternative energy sources will make only a very small contribution to Ontario's total needs during the next twenty years;
- the Ontario economy and population will develop along the lines forecast by the Ministry of Treasury and Economics.

A more detailed description of the assumptions is presented in Figure 48.

The forecast presented here takes into account neither the measures included in the National Energy Program nor those in the ten-point Oil Substitution and Energy Conservation Program announced by the Ontario government on 10 October 1980. In introducing this new program the Ontario government updated and tightened its energy policy targets for energy conservation and for the substitution of alternative fuels for those based on crude oil. The new targets are summarized in Figure 43. If those targets are reached, the growth in secondary energy consumption in the province from 1980 to 1995 will average 1 per cent annually rather than the 1.5 per cent shown in the forecast.

Annual oil consumption by 1995 would be 3.7 million cubic metres less than in 1980. Ontario would be purchasing from outside the province less than 63 per cent of its primary energy needs and would be supplying at least 5 per cent of its needs from renewable and recoverable resources such as municipal wastes, forest wastes, industrial waste heat, agricultural crops and residues, poplar plantations, synthetic liquid fuels from biomass, and solar energy.

FIGURE 48: Ontario energy consumption outlook: major assumptions

Sector	Conservation	Fuel Choice
Residential		
Old Housing	25% savings in heat requirements through thermal upgrading for oil and gas heated homes, half this level for apartments Limited conservation potential for electrically heated apartments	Some conversion from oil to natural gas and electricity
New Housing	27% reduction in heating requirements 10 - 11% improvement in efficiency of stock of furnaces and appliances by 2000	Primarily natural gas and electricity with share of electricity increasing in the 1990s
Commercial		
Old Stock	Existing office buildings are expected to reduce their energy consumption per square foot of floor area by 17% 14% reduction for retail stores 7% for hotels, recreational buildings and warehouses	Some shift from oil to gas and electricity
New Stock	Reduction in energy requirements of 21% for hotels and restaurants, 46% for education buildings, 40% for offices and retail buildings	Natural gas and electricty Increased use of heat pumps (40 - 50% of buildings constructed in year 2000) Small contribution from active solar system in year 2000
Industrial	Canadian industry energy conservation goals achieved by 1986 (10 - 15% savings); further savings of 5 - 10% by 2000; new capacity 15 - 25% below existing capacity; electricity savings of order 5 - 10%	Increased coal penetration (35% by 2000) No significant increase for self-generation of electricity (except for pulp and paper industry with 8% increase in hydraulic generation
Transportation	Fuel economy will increase due to U.S. car fuel economy standards No major technological development assumed in the bus, train, transit, and marine modes, although air transportation has largest scope for efficiency improvement	Introduction of electric car expected in late 1980s Increased dieselization of trucks Diesel share of new cars expected to reach 8.5% by 1995 Little contribution from non-conventional fuels such as methanol, ethanol, and hydrogen before end of century Growing contributions from propane powered vehicles

All Sectors: Basic socioeconomic factors
Ontario population growth rate: 0.8% per year (1980 - 2000)
Ontario Real Gross Provincial Product growth rate: 3.7% per year (1980 - 1990); 2.4% per year (1990 - 2000)

Secondary energy consumption

Projections of secondary energy consumption have been developed for the industrial, transportation, residential, and commercial sectors.

The industrial sector includes agriculture, mining, and manufacturing; the transportation sector includes road, rail, air, and marine transportation of people and goods; the residential sector includes households; and the commercial sector includes institutional, government, and privately owned commercial buildings, as well as municipal utilities.

The energy consumed by refineries, pipelines, and electrical generating stations and that used for non-energy purposes such as plastics, lubricating oil, nylon, and so on are excluded from secondary energy consumption.

The projections of secondary consumption for the four sectors were developed by estimating the size and the characteristics of the future stock of buildings and energy-using machines and appliances and by estimating the differing amounts of energy each would use.

The projections for Ontario's energy consumption, with all sectors taken together, are presented in Figure 49 by sector and in Figure 50 by fuel.

The details of secondary energy consumption for each of the four sectors are illustrated and discussed separately.

The future growth rate of secondary energy consumption by the year 2000 is expected to be lower than in the past and to average 1.5 per cent annually from 1980 to 2000.

Energy consumption in the industrial sector is growing faster than in the other three sectors. The industrial sector's share of the total expands from less than 40 per cent in 1965 and 1975 to one-half in 2000. Transportation's share remains the same over the period at about one-quarter.

The residential and commercial sectors' shares meanwhile decline steadily, from 22 and 14 per cent respectively in 1975 to 15 and 10 per cent in 2000. The four sectors therefore maintain their current rank in terms of the amount of energy used: industrial first, then transportation, residential, and finally commercial.

Between 1965 and 1975, gas and electricity's shares of the total market increased, and oil and coal's shares

FIGURE 49: Secondary energy consumption by sector 1965-2000

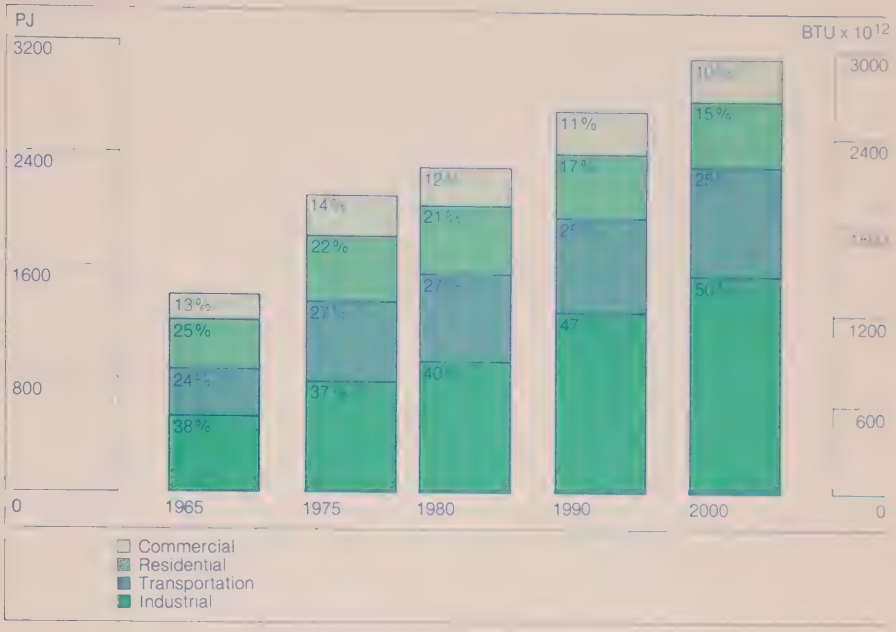
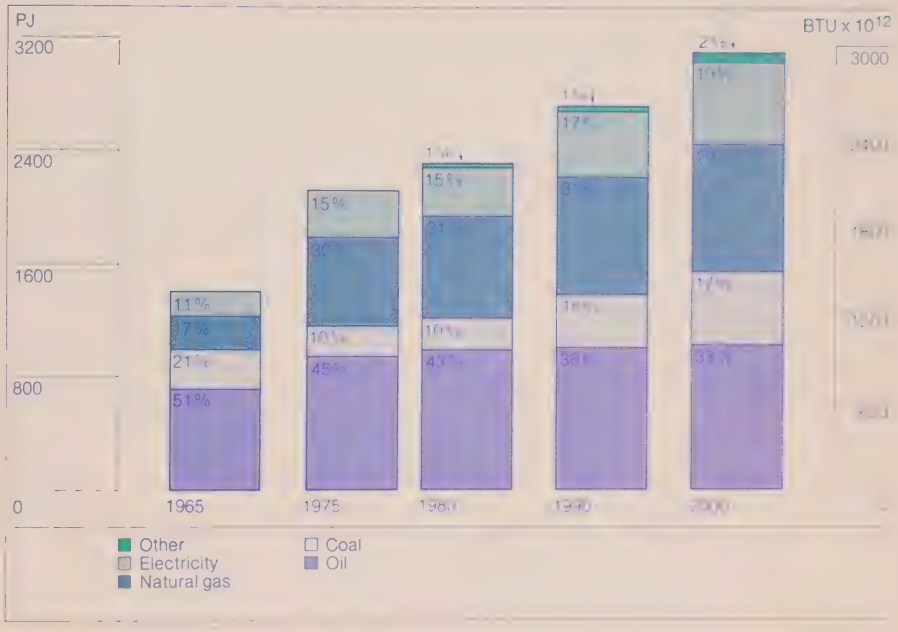


FIGURE 50: Secondary energy consumption by fuel 1965-2000



dropped (Figure 50). Over the forecast period, the shares of secondary energy consumption for electricity and coal are projected to increase, while that of oil decreases further. Natural gas's share declines somewhat in the 1990s, primarily because of a projected larger share for coal in the industrial sector and the greater competitiveness of electricity in the residential sector. By the end of the century nearly three-quarters of secondary consumption of oil is for transportation.

Primary energy consumption

To calculate total primary energy consumption, the secondary consumption of the four sectors is totalled. To this sum is added the amount of energy used by the energy supply industries, the adjustment for nuclear and hydraulic electricity, and that used for non-energy products (see 'Energy forms and conversion factors'). This calculation gives the total estimated demand for all primary energy used in Ontario in a particular year.

The recent growth and composition of the province's primary energy consumption are shown in Figure 51. Ontario's total primary energy requirements are projected to grow at an average annual rate of 2.1 per cent between 1980 and 1990 and 1.5 per cent between 1990 and 2000, averaging 1.8 per cent over the forecast period. These rates of growth are well below the historic rates of 5.3 per cent between 1965 and 1970 and 2.4 per cent between 1973 and 1978.

The future growth in primary energy consumption is projected to be slower than that of the 1960s because of the expected slower growth of the Ontario economy and the expectation that consumers and industry will take measures to improve the efficiency of their energy use.

The projections indicate a decline in the shares of oil and natural gas. By the year 2000, oil will constitute 29 per cent of total primary energy requirements and natural gas 19 per cent, down from 38 and 22 per cent respectively in 1980.

The growth of electricity demand in Ontario is expected to be slower than in the 1970s in spite of the fact that proportionally more electricity will be consumed. Electricity's greater market share will be supplied primarily from nuclear and coal-fired stations, because most of the important hydraulic sites in Ontario have already been developed. Uranium's share of primary energy increases significantly to about 25 per cent by the year 2000, whereas electricity produced from water-power drops to 9 per cent of total needs.

Fuel consumption by sector

Total crude oil consumption is forecast to rise by 10 per cent by 2000 (Figure 52). By then only 20 per cent of the oil is used for heating purposes in the residential, commercial, and industrial sectors. Transportation absorbs more than half, and petrochemical feedstocks and non-energy uses account for another 22 per cent. Although more oil could probably be saved in stationary heating applications, further large reductions in

FIGURE 51: Primary energy consumption 1965-2000

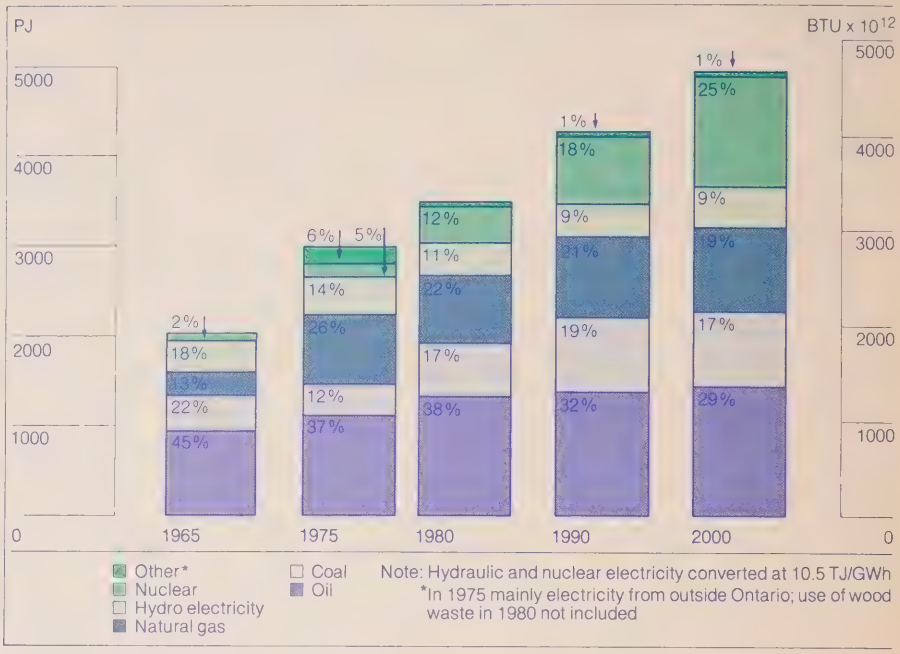


FIGURE 52: Fuel consumption by sector

	1980	2000
Electricity	398 PJ	672 PJ
Residential	27%	25%
Commercial	29%	24%
Industrial	32%	39%
Energy industry	12%	11%
Transportation	—	1%
Natural gas	749 PJ	913 PJ
Residential	26%	22%
Commercial	16%	14%
Industrial	53%	59%
Other energy uses	5%	5%
Coal	578 PJ	838 PJ
Industrial	42%	64%
Electricity generation	58%	36%
Oil	1303 PJ	1436 PJ
Residential	13%	6%
Commercial	4%	2%
Industrial	10%	12%
Transportation	48%	52%
Other energy uses	8%	6%
Non-energy uses	17%	22%
Electricity generation	1189 PJ	2016 PJ
Nuclear	35%	61%
Water-power	34%	22%
Coal	28%	15%
Other fuels	3%	2%

Note: Energy demand estimates exclude exports of electricity and refined petroleum products; 'other energy uses consist of energy industry own use and electricity generation; 'non-energy uses' include petrochemical feedstocks, lubricating oils and greases, asphalt, etc.

crude oil consumption will therefore require that conservation and substitution efforts be directed at transportation needs.

Total electricity consumption rises nearly 70 per cent in the forecast, with the industrial sector's share growing at the expense of the residential and commercial sectors.

By 2000, natural gas consumption increases by 20 per cent. Again the share of the industrial sector rises, whereas those of the residential and commercial sectors fall.

The increase in industrial consumption of natural gas, however, is limited by competition from coal, whose use increases by 45 per cent. Coal's share of electricity generation falls, because of its displacement by nuclear generation, which accounts for more than 60 per cent of electricity generation by 2000.

The projection of Ontario's secondary energy consumption presented above was for all sectors taken together. It was based on more detailed projections of energy needs for each sector. For the interested reader those sectoral projections will now be briefly outlined.

Industrial sector

Figure 53 summarizes the secondary energy consumption of the industrial sector.

Total consumption rose between 1965 and 1975 by 40 per cent.

Over the period 1978-2000, total industrial energy consumption is predicted to grow at an annual rate of 2.6 per cent. From 1978 to 1990 the growth rate averages 3.4 per cent; it drops to 2.0 per cent after 1990.

Between 1965 and 1975, electricity and oil's shares changed little, the former holding at 15 per cent, the latter dropping slightly from 20 to 18 per cent. Natural gas replaced coal as the source of more than two-fifths of the energy supply.

Our forecast indicates that the decline in coal's share will be reversed. Consumption of coal and electricity is expected to grow more rapidly than that for crude oil and natural gas. Consequently, by the year 2000, coal will meet 35 per cent of industrial energy requirements and electricity 17 per cent. Oil will decrease from 18 per cent in 1975 to 11 per cent and natural gas from 41 to 35 per cent. These declines are largely accounted for by the projected increased use of coal in response to its declining relative price.

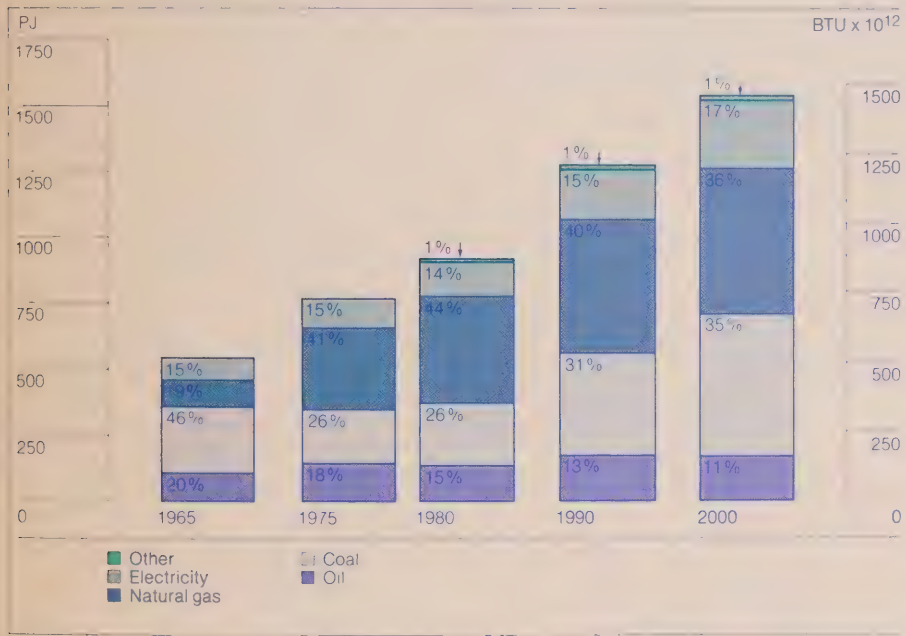
Three industries—iron and steel, industrial chemicals, and pulp and paper—now account for about half of the industrial sector's energy requirements. It should be noted, however, that the iron and steel industry uses most of its energy not as fuel but as coking coal (about 75 per cent). Efforts to reduce energy consumption in these industries include the increased use of thermo-mechanical pulping over sulphite pulping by the pulp and paper industry and the phasing out of open-hearth furnaces in favour of basic oxygen technology by the iron and steel industry.

The generation by industries of their own electricity is expected to grow considerably, particularly in pulp and paper. The potential for new cost-effective industrial cogeneration in Ontario is estimated at 700 MW, or about 3 per cent of Ontario Hydro's existing generating capacity. The pace of this development should be accelerated by the recent liberalization in the policy of Ontario Hydro for the purchase of surplus power and the provision of standby power.

Transportation sector

The transportation sector is second to the industrial sector in energy consumption. In 1975 crude oil accounted for over 99 per cent of the energy used in transportation. Consumption grew at an annual rate of 5.4 per cent between 1965 and 1975 (Figure 54), but growth is expected to be more moderate to the end of the century (averaging about 1.5 per cent annually from 1975 to 2000).

FIGURE 53: Industrial energy consumption 1965-2000



By the year 2000 passenger travel will account for just over half of total transportation energy requirements, while the freight sector and non-urban trucking will consume 38 and 7.5 per cent respectively. The remainder will be used by other kinds of transportation.

Passenger transportation is expected to grow more slowly over the next twenty years than it has in the past, because of a slowdown in population growth, an increase in the real price of gasoline, and a lower rate of increase in personal disposable income.

Automobiles will probably continue to be the dominant mode of transportation for the passenger sector, though the automobile share of the energy used for passenger transportation will fall from 88 per cent in 1978 to 80 per cent in 2000. Public transit use is expected to increase faster than automobile use because purchasing and operating an automobile will become more expensive in relation to public transit.

The relative shares of gasoline and diesel fuel will change. Diesel fuel is expected to continue increasing its share, primarily because of greater use in trucking. Although some shift to diesel engines in automobiles is expected as well, the unavailability of diesel fuel away from major highways in Ontario and cold weather performance and emission problems may constrain diesel's share of new car sales.

Propane is expected to make a growing contribution to transportation energy requirements, especially in urban fleet use.

The electric car is expected to become more common in the late 1980s and to account for approximately 3.5 per cent of new car sales by 2000.

Without specific incentives non-conventional fuels such as methanol, ethanol, and hydrogen are not expected to make a large contribution before the end of the century because of their high cost and technical and supply problems.

The Ontario government has established the Alternative Transportation Fuels Program to encourage the development and demonstration of new liquid and gaseous fuel options for vehicles.

The introduction of fuel economy standards for new automobiles will reduce energy consumption. In air travel, improved aerodynamics, new lightweight materials, higher seating densities, and changes in fuel specifications and engine design will result in efficiency gains. Technological improvements, improved operations, and changes in regulatory procedures will permit additional savings for freight transportation.

FIGURE 54: Transportation energy consumption 1965-2000

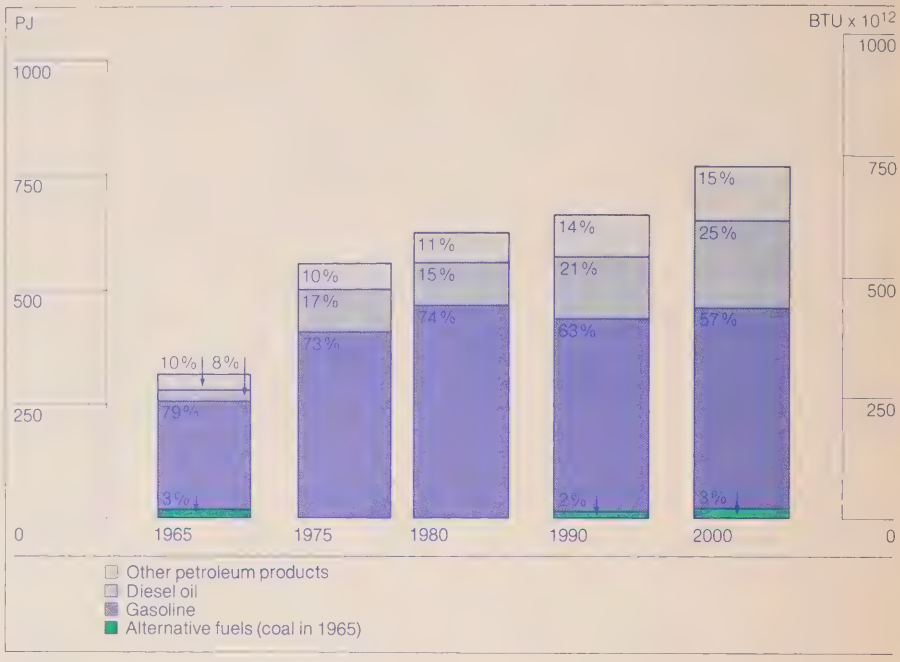
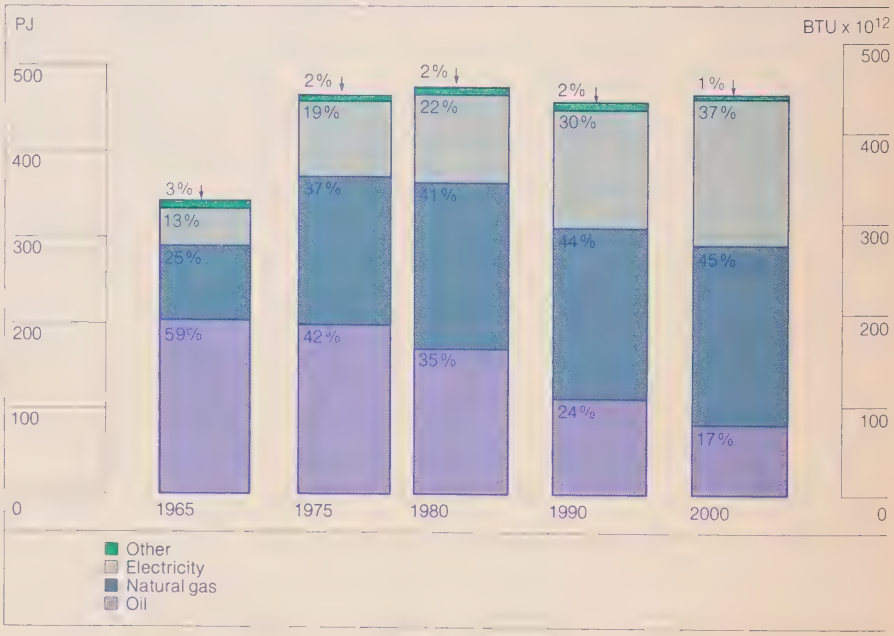


FIGURE 55: Residential energy consumption 1965-2000



Residential sector

The residential sector energy requirements consist of all the energy used for household purposes. Space heating accounts for about three-quarters of total residential consumption and water heating for 15 per cent, with the remainder used for appliances, lighting, and other applications.

As Figure 55 shows, total energy consumption in the residential sector rose by one-third between 1965 and 1975. At the same time oil's share decreased from 59 to 42 per cent. Natural gas and electricity took up the slack.

Total energy consumption in the residential sector is not projected to rise over the outlook period. Oil's share will decline to 17 per cent (from 35 per cent in 1980), while natural gas and electricity will increase their shares to 45 and 37 per cent respectively.

Expected increases in household and end-use applications are offset by projected improvements in the efficiency of energy use through upgrading existing housing stock, better energy conservation design in new housing stock, and the introduction of more efficient appliances and heating systems (such as the ultra high efficiency condensing gas furnace with a seasonal efficiency of over 90 per cent).

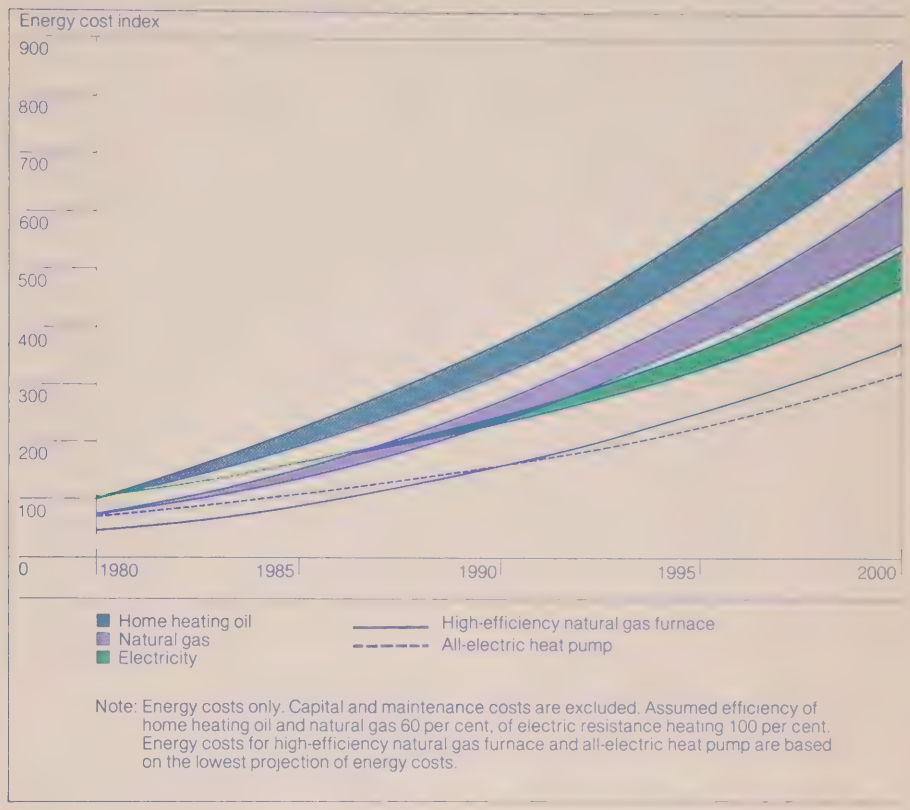
Electricity's share of the residential space heating market is expected to grow because of its improving competitiveness with oil and natural gas. Electric heat pumps providing both air conditioning and cooling are expected to increase in importance. By the year 2000, it is projected that natural gas will meet about half of Ontario's residential space heating requirements, electricity 28 per cent, and oil only 20 per cent. Natural gas and electricity will be used about equally for water heating.

Recently announced government initiatives to encourage conversion away from oil could lead to an even more rapid decline in oil's share.

Based on Ontario government estimates of heating costs for various heating systems and dwellings, the relative costs of the different fuels for home heating for the next decade have been projected (Figure 56). The increasing competitiveness of electricity for this use is easily seen.

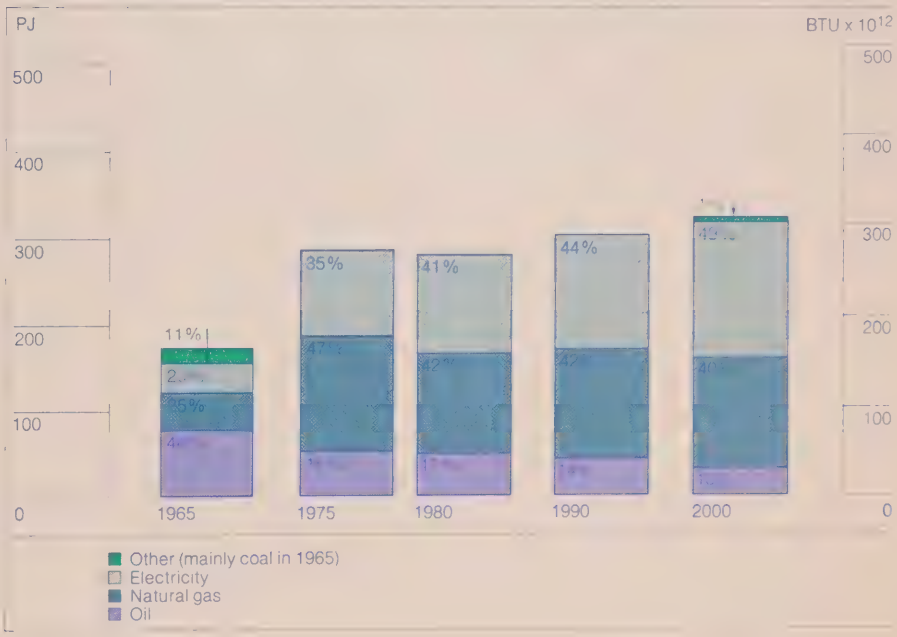
Active solar energy systems could displace from 0.4 to 2.1 per cent of total sectoral requirements by the end of the century. Two-thirds of this contribution could be for domestic water heating, the rest would be for space heating and swimming pool heating. District heating, however, will not have a significant impact before 2000 because of long lead times and high initial capital costs.

FIGURE 56: Future home heating costs



Note: Energy costs only. Capital and maintenance costs are excluded. Assumed efficiency of home heating oil and natural gas 60 per cent, of electric resistance heating 100 per cent. Energy costs for high-efficiency natural gas furnace and all-electric heat pump are based on the lowest projection of energy costs.

FIGURE 57: Commercial energy consumption 1965-2000



Commercial sector

Total energy consumption in the commercial sector is expected to grow very slowly (Figure 57). The average annual growth rate during 1980-2000 is projected to be 0.7 per cent, compared to the 4 to 5 per cent experienced in 1965-75.

In the past fifteen years, electricity and natural gas have steadily increased their shares of commercial sector energy consumption, whereas the shares of oil and coal have declined as users have switched to natural gas. Natural gas and electricity are projected to be the main choices for the future. Both will contribute to oil substitution, with electricity making up most of the market share lost by oil after 1990. A small contribution from active solar systems may be made by the year 2000.

Two factors contributing to increased energy consumption in the commercial sector are the growing use of air conditioning and increased automation. Electricity requirements will increase as greater use is made of computers and word processors in offices and diagnostic and monitoring equipment in hospitals.

Such increases will be offset by lower economic growth, falling school enrolments, policies to contain the growth of government, and strong conservation efforts. The use of heat pumps, thermal storage, and heat recovery systems will become increasingly economical and help reduce energy needs.

The province's future energy supply is, if anything, even harder to forecast than its demand. In the year 2000 Ontario is expected to need about 37 million cubic metres of crude oil, 24.5 billion cubic metres of natural gas, 28 million tonnes of coal, 2800 tonnes of uranium, and 43 million megawatt hours of hydroelectricity (Figure 50).

Ontario relies on outside sources of supply and hence on the decisions of other governments for almost all of its hydrocarbon fuel supplies. While Ontario receives almost all its petroleum requirements from western Canada, the eastern provinces depend on supplies from unstable world oil markets. In the event of a world oil supply crisis, available Canadian oil supplies would be shared with these provinces and, if required by the International Energy Agency, with other member nations. Clearly, Ontario is not isolated from the inherent uncertainty of international events.

Because of the uncertainties of supply, forecasts must be stated in terms of alternatives and probabilities. The energy demand projections above are based on various supply assumptions. Uncertainties in the supply outlook thus become uncertainties in the consumption forecast. Canada and therefore Ontario face two chief supply risks: international crude oil supply disruptions by major producing countries and a failure to proceed with Canadian oil sands, heavy oil, and frontier development in a timely fashion. Barring these two occurrences, the consumption projections presented earlier provide a reasonable picture of the range of alternatives likely to prevail in Ontario.

The following is a brief summary of where Ontario's energy supply is likely to come from.

Oil

The projections show a declining role for oil in meeting Ontario's total energy requirements.

Total Ontario oil consumption in the year 2000 has been projected at 102 000 m^3/day. This amount is only about 4 per cent above actual consumption in 1979, which was higher than the level projected for that year. Consumption in 1980 is closer to the projected amount. Nearly 75 per cent of it will be used for non-energy petrochemicals or for transportation fuels. The scope for reducing Ontario's requirements further without major technological development is therefore limited unless there is significant government intervention.

Production from established conventional oil reserves in western Canada will decrease greatly over the next ten years. New discoveries of western conventional oil are expected but will probably not offset the drop in conventional production. Tertiary recovery and other new methods of oil extraction will make a growing contribution, but they will not completely meet the shortfall either. Major oil sands plants operating now provide about 24 000 m^3/day of premium quality oil. Other plants are planned but may not be made operational rapidly enough to satisfy the gap between projected Canadian demand and domestic supply until the 1990s.

There is encouraging evidence of major deposits in the frontier areas and off the east coast of Canada, but their short-term contribution is likely to be small. The federal National Energy Program warns against counting on these areas to solve the oil supply problem.

The only sure way to guard against oil supply interruption is for Canada to become self-sufficient in oil. According to the National Energy Program, oil importation into Canada is expected to reach zero by 1990. Whether this objective will be achieved is still in doubt. But the mechanisms proposed are to reduce the consumption of oil, primarily through conservation and the substitution of more plentiful fuels, and to increase domestic supply.

However, it may take some time to moderate oil demand, whereas Canada's conventional oil supply is expected to dwindle rapidly. Imports of oil may consequently increase for the next few years before beginning to decline.

Natural gas

Ontario's natural gas use to the year 2000 is projected to show an average growth rate of 1 per cent a year. Growth in sales depends closely on consumers' seeing that future supplies are reasonably secure. What, then, are the prospects for future supplies?

Alberta provides 99 per cent of Ontario's natural gas. The bulk of this supply comes from Alberta under a removal permit issued to TransCanada PipeLines and due to expire in 1994. The Alberta Energy Resources Conservation Board (AERCB) controls the quantity of gas removed from the province in the interest of Alberta's own future consumers. In a recent review of natural gas removal applications, the AERCB has estimated the province's potential reserves to be in the order of 3700 to 4000 billion cubic metres.

Recent National Energy Board projections suggest that conventional producing areas in western Canada will be capable of satisfying both domestic requirements and existing export commitments beyond 1990.

Eventually the conventional gas supply from Alberta is expected to be supplemented or replaced by supplies from the Mackenzie Delta, the Beaufort Sea, the Arctic Islands, and other frontier areas, as well as from the gasification of coal. Explorations in the Beaufort Sea, the Arctic Islands, and off the coast of Labrador, for instance, promise significant new gas sources, though a great deal more work is required before evaluations can be made. Moreover, there is little doubt that substantial new natural gas supplies exist, but it is also apparent that they will be more expensive and that much time will be required to find and develop them and transport them to market.

At present, about 411 billion cubic metres of natural gas are authorized for export to the United States. Should domestic requirements exceed forecast levels or domestic supplies fail to meet expectations, the National Energy Board would reconsider this amount.

An increase in the demand for natural gas is expected because it will be substituted for crude oil. However, even with much substitution and a pessimistic supply outlook, Canadians should have sufficient natural gas available for the foreseeable future.

Coal

The demand for metallurgical coal in Ontario is expected to increase at roughly 2 per cent a year until 2000. The longer-term demand for thermal coal is less certain and could vary widely from year to year, but if future oil and gas supplies become uncertain the demand for thermal coal would probably grow rapidly. Total coal use in Ontario could nearly double, from around 17 million tonnes at present to nearly 30 million tonnes by the year 2000.

This level of coal consumption would be small compared with the vast reserves of coal that exist in conventional producing areas of western Canada. Research, development, and demonstration programs are being conducted in Canada and throughout the world on coal gasification, coal liquefaction, coal to make petrochemical products, and fluidized bed combustion. Progress is being made in all these areas.

However, the present high transportation cost of moving coal from western Canada to Ontario could limit access to the largest coal reserves.

Coal nevertheless represents a fairly secure long-term energy source in Canada, and future technological development could have a very significant effect on its rate of development.

Electricity

The long-term growth in electrical energy use is expected to be slower than in the past, though its share of the energy market will increase. The committed generation-expansion program and other projects under consideration, including medium-scale hydroelectrical schemes, development of lignite coal resources in northern Ontario, joint-venture industrial co-generation schemes, new coal and nuclear units, and the like, together ensure that Ontario consumers will probably not experience generation-related electricity shortages in the foreseeable future. However, difficulties in getting the necessary approvals for transmission lines to carry the electricity to the consumer may pose some supply problems in the later 1980s.

Two interrelated uncertainties of energy supply confront Ontario and Canada: crude oil supply disruptions by the major producing countries and failure to proceed with timely development of oil sands, heavy oil, and frontier energy sources. Solving the second uncertainty will in the longer run eliminate the first.

A greater degree of Canadian energy self-sufficiency seems possible and with it the prospect of freeing Ontario from many of the consequences of world energy disruptions. The province will of course never be totally isolated from world energy problems. But with self-sufficiency of oil assured and with serious conservation efforts, the worst effects of a world crude oil shortage can be alleviated.

Energy forms and conversion factors

In this publication metric units are predominantly used in accordance with the International System of Units (SI). Conversion factors to the imperial system are summarized below.

The following natural units and equivalent heat value conversion factors are used:

Metric units

Energy form	*Heat value*
Petroleum (per thousand cubic metres)	Terajoules (TJ)
Crude oil	38.512
Liquefied petroleum gases	27.177
Motor gasoline	34.656
Aviation gasoline	33.518
Aviation turbo fuel	35.934
Kerosene	37.676
Diesel and light fuel oil	38.675
Heavy fuel oil and still gas	41.727
Petroleum coke	42.376
Natural gas (per million cubic metres)	37.229
Coal (per thousand tonnes)	
Anthracite	29.527
Imported bituminous	29.993
Canadian bituminous	29.295
Sub-bituminous	19.763
Lignite	15.345
Coke (per thousand tonnes)	28.830
Coke oven gas (per million cubic metres)	18.614
Electricity* (per gigawatt hour)	3.600
Methanol (per thousand cubic metres)	18.100
Wood (oven-dried per thousand tonnes)	20.000
(50% moisture per thousand tonnes)	10.000
Municipal solid waste (per thousand tonnes)	11.400

* This conversion factor is the heat value and is used for secondary energy calculations. For primary energy calculations the conversion factor (10.5 TJ/gigawatt hour) is adopted for hydraulic, nuclear, and purchased electricity; this is the equivalent thermal energy, assuming the efficiency of conversion is that of a coal-burning plant.

Other forms

Propane (per thousand cubic metres)	25.600
Ethanol (per thousand cubic metres)	23.200

Imperial units

Crude oil	1 cubic metre (m^3) (at 15°C) = 6.293 barrels (at 60°F)
Natural gas	1 cubic metre (m^3) (at 101.325 kPa and 15°C) = 35.301 cubic feet (at 14.73 p.s.i.a. and 60°F)
Coal	1 tonne (t) = 1.102 short tons
Energy	1 joule (J) = 0.000948 BTU

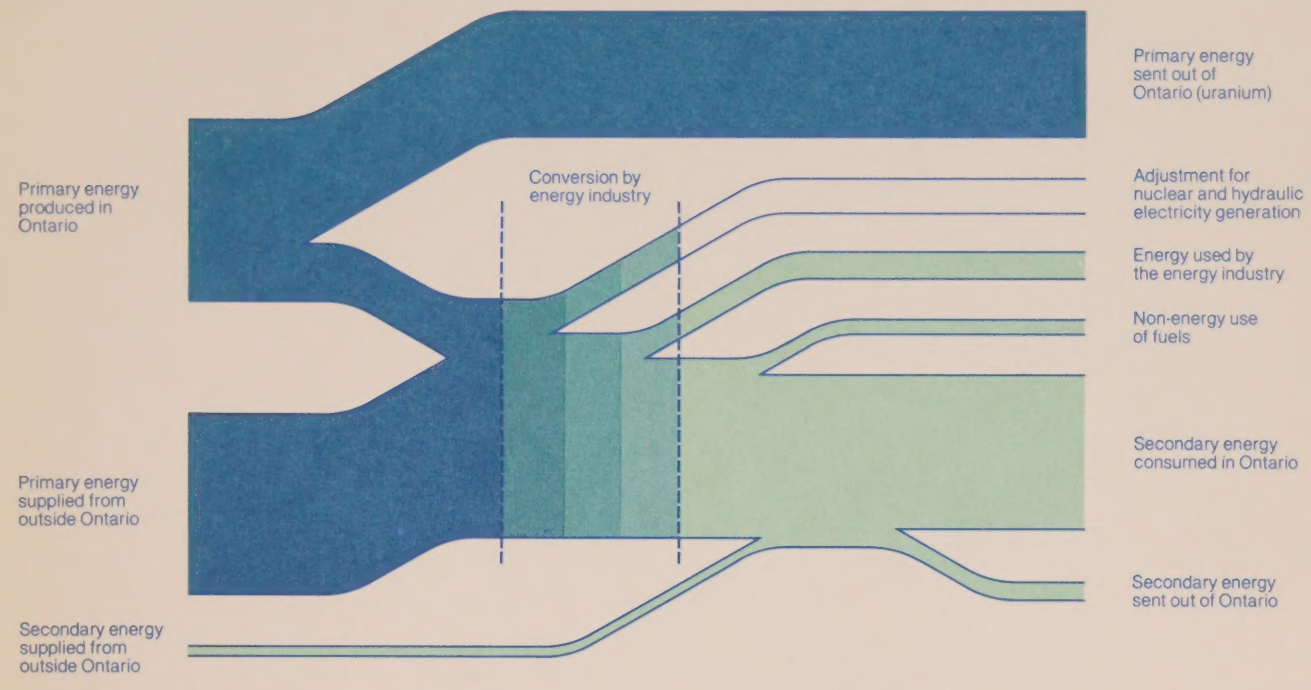
kJ = kilojoule = 10^3 J
MJ = megajoule = 10^6 J
GJ = gigajoule = 10^9 J
TJ = terajoule = 10^{12} J
PJ = petajoule = 10^{15} J

Preliminary statistics for January - September 1980

	Ontario		Canada		Year 1979	
Energy form	1980	1979	1980	1979	Ontario	Canada
Oil			thousand cubic metres/day			
Production	0.3	0.3	254	256	0.3	256
Consumption	92	97	289	294	99	300
Imports	–	–	88	95	–	97
Exports	–	–	33	46	–	46
(Exports and imports include U.S. exchange oil)						
Natural gas			thousand cubic metres/day			
Production	928	781	183 345	202 290	800	209 000
Consumption	50 185	52 569	118 859	123 548	53 200	159 040
Imports	–	–	7	6	–	6
Exports	1 105	1 180	59 170	74 267	1 360	78 000
Propane			cubic metres/day			
Production					1 428	21 022
Consumption			not available		7 430	9 820
Exports					4 545	12 632
Coal			million tonnes/year			
Production	–	–	26.7	24.4	–	33.0
Consumption	9.8	9.5	19.2	16.6	17.6	34.5
Imports	10.9	11.9	11.3	12.0	17.1	17.4
Exports	–	–	11.5	10.7	–	13.6
Uranium			tonnes/year			
Shipments	4 275		6 368		4 419	6 956
Consumption			not available		686	980
Exports					3 733	5 976
(Estimates for year 1980. Shipments include production and inventory.)						
Electricity			terawatt hours/year			
Production (net generation)	82	81	267	258	109	352
Consumption	78	77	247	236	104	323
Imports	5	5	3	2	8	2
Exports	9	9	22	23	12	31
(Imports and exports for Ontario include deliveries to or from other provinces)						

Note: The statistics in the Ontario Energy Review are derived from industrial surveys and consequently become available only gradually. The diagrams in the Review, being based on annual statistics, could only be drawn up to 1979. This table presents the statistics on 1980 to the extent that they were available at the time of printing.

Primary and secondary energy in Ontario



Note: Channel sizes are proportional to energy content in 1979. Primary energy content of uranium produced for export in Ontario assumes 1 tonne of uranium is equivalent to 539.7 TJ; its secondary energy content will depend on the conversion technology used.

The 'consumption' of energy means the conversion of latent energy in nature to heat, and in particular the controlled generation of heat and light by end-users.

'Primary energy' denotes the energy content of the raw materials from which consumer forms of energy are made. 'Secondary energy' is that which is consumed. Thus crude oil is a form of primary energy, while the consumer products made from crude oil, such as gasoline, diesel fuel, and heating oil, are forms of secondary energy. Electricity is classed as secondary energy.

During the conversion process in which secondary energy forms are manufactured, some of the energy of the primary form is consumed. This energy is termed in the Review 'energy used by the energy industry.'

An adjustment is made by the use of a conversion factor (see list on opposite page) to calculate the primary energy input for nuclear and hydraulic electricity generation.

Another portion of the primary energy goes to 'non-energy use,' such as that converted into petrochemical feedstocks in the manufacture of plastics, lubricants, and asphalt.

These three amounts as well as the secondary energy sent out of the province are excluded from Ontario's secondary energy consumption.

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